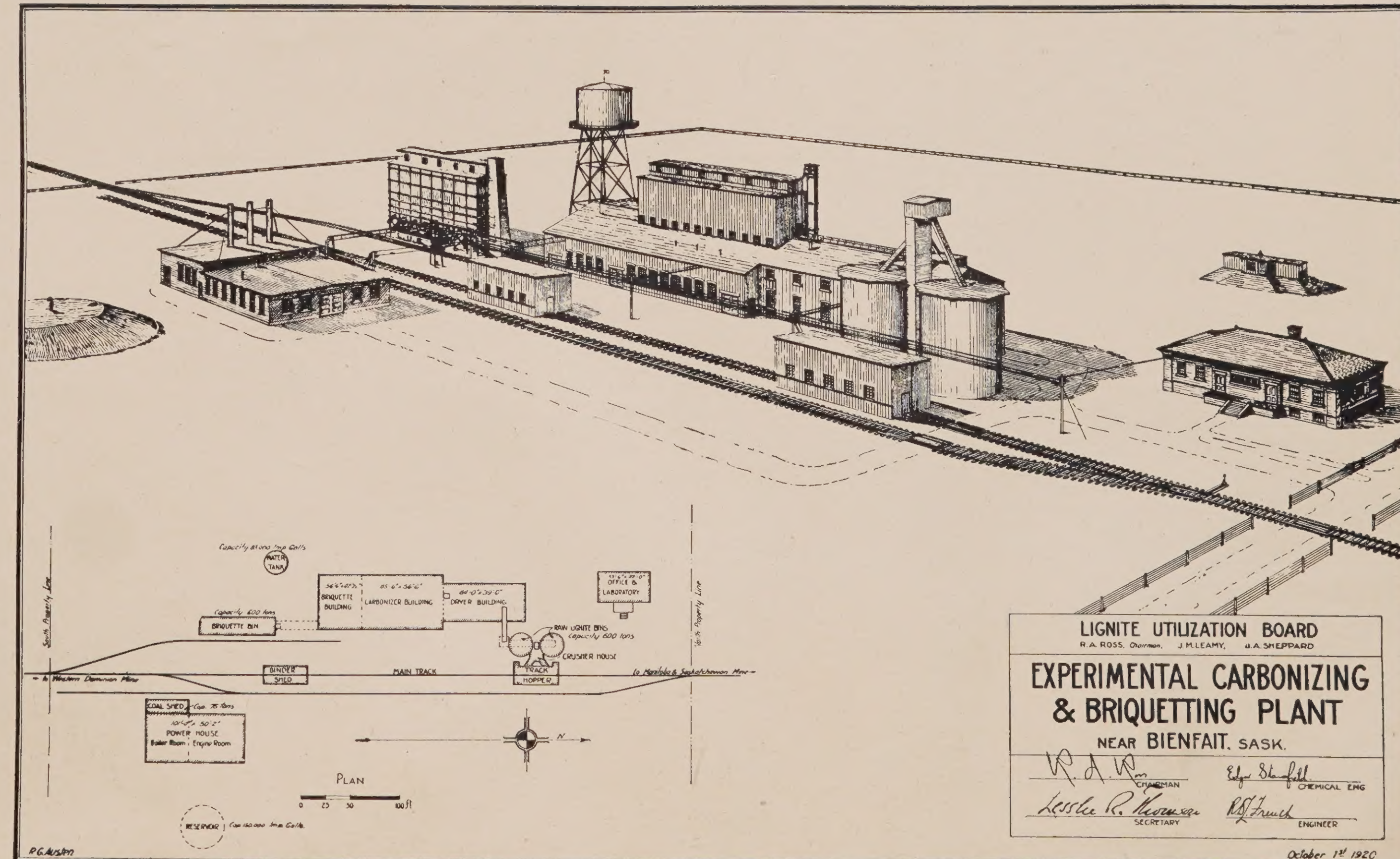
FIRST GENERAL REPORT

OF THE

LIGNITE UTILIZATION BOARD OF CANADA

COVERING OPERATIONS

OCT. 1st 1918
TO
JAN. 1st 1924


LIGNITE UTILIZATION BOARD
R.A. ROSS, Chairman, J.M. LEAMY, J.A. SHEPPARD
EXPERIMENTAL CARBONIZING & BRIQUETTING PLANT
NEAR BIENFAIT, SASK.
CHAIRMAN
CHEMICAL ENG
SECRETARY
ENGINEER
October 1st 1920
PLAN
WATER TANK
Capacity 600 tons
BRIQUETTE BIN
BRIQUETTE BUILDING
CARBONIZER BUILDING
DRYER BUILDING
OFFICE & LABORATORY
RAW LIGNITE BINS
Capacity 600 tons
CRUSHER HOUSE
TRACK HOPPER
BINDER SHED
MAIN TRACK
COAL SHED
POWER HOUSE
Boiler Room
Engine Room
RESERVOIR
South Property Line
North Property Line
to Western Dominion Mine
to Manitoba & Saskatchewan Mine
N
0 25 50 100 ft
R.G. Austen

Canada. Lignite Utilization Board

THE
LIGNITE UTILIZATION BOARD
OF CANADA

Created in 1918 by Order-in-Council of the
Dominion Government.

§

FIRST
GENERAL REPORT

OF THE

LIGNITE UTILIZATION BOARD
OF CANADA

Covering Operations

OCT. 1st, 1918,
TO
JAN. 1st, 1924.

Submitted to

THE HON. CHARLES STEWART
Minister of Mines
OTTAWA

PRICE $1.50
after free circulation is exhausted.

Published, March 15, 1924,
by
THE LIGNITE UTILIZATION BOARD OF CANADA,
288 St. James Street, Montreal

PERSONNEL OF
THE LIGNITE UTILIZATION BOARD

R. A ROSS, E.E., D.Sc., M.E.I.C.,
MONTREAL — CHAIRMAN.

J. M. LEAMY, M.E.I.C.,
WINNIPEG, MAN.

HON. J. A. SHEPPARD,
MOOSE JAW, SASK.

LESSLIE R. THOMSON, M.E.I.C.
SECRETARY.

ARRANGEMENT OF REPORT

NOTE: The within report is divided into the following divisions:—

LETTER OF TRANSMISSION

MONTREAL, *February 8, 1924.*

HON. CHARLES STEWART,
Minister of Mines,
Department of Mines,
Ottawa, Ont.

Dear Mr. Stewart:—

As requested I am forwarding under this cover two (2) signed type-written copies of the first general report of the Lignite Utilization Board, dated January 26th, 1924, covering the period of its operation from October 1st, 1918, to January 1st, 1924.

In order not to delay the dispatch of this document, and in view of the lack of any request from you for the Board's recommendations on future action, the report confines itself exclusively to a record of the activities of the Board during the past five years. No mention is made of the financial aspects of those plant revisions deemed necessary to attain the original objective of a commercial demonstration. In order, however, that you may have this information when desired, we propose to forward to you shortly a special memorandum on this specific question.

On behalf of the Board, I remain,

Very truly yours,

(*Signed*) R. A. ROSS,
Chairman.

FIRST GENERAL REPORT

OF THE

LIGNITE UTILIZATION BOARD OF CANADA

TO

The Honorable Charles Stewart
Minister of Mines
Ottawa

Montreal, *January 26, 1924.*

The Hon. Charles Stewart,
Minister of Mines,
Ottawa, Ont.

Sir:—

The following first general report of the Lignite Board is submitted in response to your request of Sept. 25th, 1923, and covers the period from the start of the Board's work, October 1st. 1918, to December 31st. 1923.

The fuel stringency in Canada due to the war began to be acute in 1916. At the beginning of 1917 the Research Council appointed a Fuel Committee to study the Western lignite problem. This Committee called into immediate consultation representatives of those Dominion Government departments especially connected with fuels — namely, the Department of Mines, and the Commission of Conservation. As a result of these consultations the Department of Mines and the Commission of Conservation made certain investigations and special reports touching upon the question of the utilization of lignite for domestic use by carbonizing and briquetting. Agreeing with these reports, and focusing the opinion held by all parties to the preliminary review, the Fuel Committee recommended to the Research Council that a commercial demonstration of this process be made. In turn the Research Council recommended appropriate action to the Government — contemplating that its execution would rest with the Federal Department of Mines. Owing however to reasons outlined in Exhibit A, it was decided to create a special Board to undertake the work.

The authority for the creation of the Lignite Utilization Board, its status, the relationships between the supporting Governments, and the personnel of the Board itself, are found in Dominion Order-in-Council No. P. C. 643 dated March 20th 1918, in Dominion Order-in-Council No. P. C. 2064 dated August 22nd 1918, and in a tripartite agreement dated July 20th 1918, signed by representatives of the Dominion Government, the Manitoba Government and the Saskatchewan Government.

With the above described status the Board began its work on October 1st, 1918, with the objective (laid down by Order-in-Council) of

demonstrating *the commercial feasibility of producing a carbonized lignite briquette for domestic consumption.*

When the work was started it was believed that the technical process had been developed beyond the laboratory stage. Upon personal investigation undertaken by the Board of all processes and plants in America, (Europe was closed at that time), it became very apparent that no commercial process for the treatment of lignites was available. It therefore became necessary for the Board to develop the technique of a *process* before any hope could be entertained of giving a commercial demonstration of the project.

The fundamental research necessary to produce such a process occupied the Board from February, 1919, until the spring of 1920. This entirely unexpected delay not only kept back the attainment of the objective by an equivalent amount of time, but also precipitated the construction of the plant into the most expensive building period ever experienced, a time quite unprecedented as far as prices and deliveries were concerned.

During the prosecution of the research just mentioned a process gradually began to develop. On account of previous work done in Ottawa by the Department of Mines, the Board's engineers felt that the development of apparatus suitable for the commercial carbonization of lignite was a more difficult problem than the development of a process of briquetting. Attention therefore was concentrated on the carbonizing from February 1919 to October 1919, by which time it was felt that the principle and operation of a new type of by-product retort had been developed to a sufficient degree to permit the Board to move forward to the construction of its main plant. In other words, as the objective of the Board lay in a commercial demonstration, the inevitable risks always incident to full scale development of new processes had to be taken boldly and at once, as no laboratory experiment can ever give a satisfactory commercial demonstration. The commercialization of a process involves inevitably the operation of full scale commercial units.

With this view clearly held, construction of the Bienfait plant was started in June 1920, and the plant was finished in August, 1921.

The autumn of 1921 was thereupon given up to attempts to get the plant into operation. After these trial runs, all parts of the plant appeared reasonably satisfactory, with the exception of the carbonizing ovens and certain mechanical features of the briquetting layout. Of these two departments the carbonizing presented the graver and more ominous difficulties. After thorough investigation it was decided to rebuild three of the carbonizers in order to incorporate such changes as the preceding few months trials had indicated as essential. These changes were completed by August 31st, 1922, and trial runs were again instituted with a great reduction in the operating difficulties encountered. Successive attempts were made to operate the carbonizers, but by the beginning of January 1923, it became evident that hope would have to be abandoned of making these by-product carbonizers commercial. During this time a large number of further runs had been made in the briquetting building, which indicated that

the layout and sequence of the machinery was far from right. The difficulties encountered lay in mechanical troubles with machinery rather in any mystery surrounding the *process*. In other words, it was a matter of accommodating large scale machinery to the execution of a process the details of which in small apparatus had been mastered in Ottawa.

The situation then in the beginning of 1923 was as follows: The Board's own carbonizers were proved non-commercial. The full scale briquetting layout had proved not to be as suitable as it ought for the carrying out of the process developed in Ottawa. Therefore it was apparent that the real gap in the process was in carbonizing though the attainment of a complete process was an *absolute* prerequisite to any commercial demonstration of the project. In this contingency the Board turned to the investigation of a new type of shaft carbonizing oven developed within the preceding few months by the combined efforts of the American Bureau of Mines and Dean Babcock of the University of North Dakota. Through the courteous co-operation of Messrs. Hood and Odell of the American Bureau, and of Dean Babcock, the Board made a test of Souris lignites at Grand Forks in the one example of this oven then existing. The results of this run were sufficiently encouraging to warrant the Board in erecting at Bienfait one large size oven of this type with the idea of giving the principle and construction details a very thorough test. The retort was completed on June 23rd, and from the beginning of July to the end of December, 1923, was operated practically continuously with proper gas offtake connections during which time 3000 tons of lignite were carbonized. As the result of this run the Board states that within specific limits covered by the claims for this oven (see appendices) the oven can be termed a commercial success.

In order to demonstrate that the char produced by this oven is suitable for and can be briquetted, the supporting governments instructed the Board to briquette 150 tons at the briquetting plant of the University of North Dakota at Hebron. Again Dean Babcock courteously acquiesced, and the briquetting test on this char held in December 1923 gave absolutely successful results.

The Board has now reached the point where it can announce that taking in order the necessary steps to produce a carbonized lignite briquette for domestic consumption, the *technical process has been completely demonstrated with full scale apparatus suitable for commercial conditions.* It now remains (in order to reach successfully the objectives laid down by Dominion Order-in-Council) to give a working commercial demonstration of this process, without which the whole project will have proved abortive.

The Board therefore submits the following as a brief digest of its work and results over a period of 5 years.

The Lignite Utilization Board started work October 1st. 1918 and to date over five years have elapsed.

This time has been spent as follows:

OCCUPATION	Time in years approx.	REMARKS.
Investigation of all previous work.	½	To insure that the Board would have complete information as to development of the process in America.
Fundamental research	1	Necessitated by discovery that no lignite carbonizers were developed to a commercial degree in America.
Construction and equipping of plant.	1	Construction very slow owing to conditions obtaining in 1920-21.
Trial operations and reconstruction	1-½	Attempts to operate Board's own carbonizers, reconstruction of same, and renewed efforts—their final abandonment.
Demonstration of process now proved.	1	Investigation and demonstration of Hood-Odell oven. Briquetting of char. Completion of process demonstration.

The following is an approximate statement of receipts and expenditure from October 1st, 1918, to January 1st, 1924.

RECEIPTS:—	*Approx.*		
From Governments	$1,036,300		
" Misc. Sources (Interest etc.)	13,900		
" House Rentals and special Services a/cs	9,500		
			$1,059,700
EXPENDITURE:—	*Approx.*	% of Total Receipts.	
Administration	$141,600	13.3%	
Travelling	12,800	1.2%	
Capital exp. in dwellings and Boarding house	117,700	11.1%	
Capital exp. in Plant Bldgs., Equipment, Ovens, etc.	604,700	57.1%	
Preliminary Operating, Maintenance and Repairs	107,200	10.1%	
Miscellaneous	8,300	0.7%	
Cash in Hand	67,400	6.5%	
		100.0%	$1,059,700

All above accounts were audited to March 31st., 1923.

Results

Making no allowance for any subsequent development of the work either by this Board or others, the following constitutes a brief digest of the actual results obtained:—

i) Immediately upon its inception in 1918, the Board started a complete investigation of all existing methods of carbonizing and briquetting of lignite with the discovery that *no* commercial processes had been developed.

ii) This discovery necessitated the embarking upon an extensive fundamental research into the chemistry and physics of lignite carbonization with a view of developing the basic information that would enable the Board to develop a process. This work was done with the active co-operation of the Department of Mines, Ottawa. The information thus gained is available permanently.

iii) As the work developed, semi-commercial carbonizing and briquetting plants were erected in Ottawa. The operation of these plants yielded information of considerable value, also available permanently.

iv) A very thorough test has been given to a special type of lignite carbonizer, and it has been proven non-commercial. Therefore one important ghost has been laid.

v) The Board has erected a large plant of a solid permanent character at Bienfait, and for the operation thereof, has provided housing, water supply, power, chemical control laboratories, and complete mechanical equipment.

vi) The Board has aided materially in the development of a shaft oven carbonizer designed by the combined efforts of Messrs O. P. Hood and W. W. Odell of the American Bureau of Mines, and of Dean Babcock of the University of North Dakota. This advance has been made possible by the very courteous co-operation extended by each of these three. During this work the American Bureau acted as consulting engineers to the Board.

vii) The Board has solved the technical problems of briquetting lignite char. All known binders were experimented with in Ottawa, and the most economic selected for commercial development at Bienfait. In addition the Board has demonstrated under instructions from the three supporting governments, that the special char from the Hood-Odell oven presents no peculiar difficulties in briquetting, for 150 tons of this char, produced at Bienfait, were briquetted at Hebron successfully, through the co-operation of Dean Babcock, the University of North Dakota.

viii) From the foregoing it is obvious that a *complete process* of making carbonized lignite briquettes has been demonstrated absolutely successfully, with full scale equipment. Thus the first half of the original objective *laid upon the Board has been attained.*

Still to be Demonstrated.

The second half of the original objective laid down by Order-in-Council is the commercial demonstration of the process now perfected,

including commercial quantity production and sale of product for at least six months. This demonstration can be made at the Bienfait plant, (provided certain revisions be incorporated). These changes include alteration to the briquetting layout, installation of the necessary additional carbonizing ovens, improvement of methods of water disposal, and of the shipping and switching facilities, and the completion of those revisions to conveyors and handling equipment, necessitated by change in carbonizing process. The necessity for commercial throughput lies in the fact that only by operation in quantity can there be determined the commercial cost of, materials, labour, repairs, replacements and technical supervision and control. If this step be not taken then the money already invested will have been largely wasted, for no commercial company will accept a process developed solely on its technical side. The alternatives are completion of objective with saving of funds already expended, or failure of project with resulting loss of capital.

The details of all the above mentioned matters are covered fully in a report dated Jan. 24th, made to the Board by the Secretary, Lesslie R. Thomson, the text of which, with its appendices, appears as Exhibit "A" of this report of the Lignite Utilization Board.

Respectfully submitted,

LIGNITE UTILIZATION BOARD OF CANADA

(*Signed*) R. A. ROSS,
Chairman.

(*Signed*) J. A. SHEPPARD,
Member.

(*Signed*) J. M. LEAMY,
Member.

MONTREAL, *January 26th, 1924.*

All of the following material constitutes EXHIBIT "A" *of the foregoing report.*

Overleaf on p. 13 will be found a general index of Contents, Appendices, Plates and Figures, while on p. 101 will be found a brief glossary of technical terms

INDEX

OF

EXHIBIT "A".

BEING A

REPORT TO THE LIGNITE UTILIZATION BOARD

BY THE SECRETARY

LESSLIE R. THOMSON.

REPORT

TO THE

LIGNITE UTILIZATION BOARD

BY

LESSLIE R. THOMSON

Secretary.

PREFACE

The history of the Lignite Utilization Board divides itself naturally into a number of successive chronological periods, each quite distinct from the other as regards its special objectives and accomplishments.

In casting about for a logical method of presenting a lucid and precise record, the Board gradually came to the opinion that, as carbonizing had been, since the inception of the project, its most important division, and as carbonizing moreover had been the source of all the major troubles, it would be best to build up the body of the narrative report about that theme, and relegate all other matters to auxiliary special sections.

Consequently the following report traces chronologically the history of the Board from the point of view of its complete dependence on the technical and commercial results of the long struggle to solve the problem of carbonizing. With commercial failure here, success in other fields is valueless to this work. The Board must stand or fall on the result of its efforts to carbonize commercially, — and success there, makes possible success all along the line.

During the course of its work the Board naturally had to make extensive researches into the field of briquetting, and the results of its efforts in that department are presented in section VIII.

Other sections are added on finance and on miscellaneous matters, including — investigations, processes, staff, construction proposals made by others to the Board, etc.

From the inception it has been felt that the work could only be completed if pushed to a commercial demonstration. This has not yet been done, and it is therefore necessary to present a record of an undertaking still quite inconclusive as to its commercial aspects, and hence not a real fulfilment of the objectives laid down originally by Order-in-Council of the Dominion Government. While noting this fact attention may be called however, to the large amount of knowledge gained by the research and investigation of the Board, which knowledge is now available permanently.

During the progress of the work a considerable amount of investigation on lignite was undertaken very courteously by other individuals

and corporations. The Board wishes, therefore, to record very gratefully the co-operation and assistance rendered by :

American Cyanamid Company	New York, N. Y.
Professor Bone,	London, Eng.
J. A. Davis, Supt. Alaska Station, Bureau of Mines,	Pittsburgh, Pa.
Fusion Corporation Limited,	Middlewich, Eng.
General Briquetting Company,	New York, N. Y.
International Coal Products Corporation,	Irvington, N. J.
Dr. Klein, Municipal Laboratories,	New York, N. Y.
Low Temperature Carbonization Limited,	London, Eng.
Mr. F. E. Lucas, Dominion Iron & Steel Co	Sydney, N. S.
Professor Layng, University of Illinois,	Urbana, Ill.
C. Mertz, Esq.	Jamaica, N. Y.
Theodore Nagel, Cyanamid Company,	New York, N. Y.
Professor Parr, University of Illinois,	Urbana, Ill.
Peatral Syndicate Limited,	London, Eng.
Dr. Rouse, (Rouse & Campion)	London, Eng.
C. H. Smith, Esq., Carbocoal,	New York, N. Y.
Professor E. Schoch,	Austin, Texas
Mr. A. L. Stillman, Vice President, Gen. Briq. Co.,	New York, N. Y.
Messrs. Wheeler & Woodruff,	New York, N. Y.

The Board is indeed very grateful for the investigatory work kindly undertaken by each of the foregoing. Some of it is referred to in the text of the following report.

There are also other acknowledgements the Board wishes to make specifically at this time.

Since the inception in 1918 of this special lignite work under a separate commission, the Canadian Department of Mines has extended every courtesy and facility to the Board. This was especially valuable during the conduct of the fundamental research at Ottawa in 1919 and 1920, during which time a laboratory was maintained in Ottawa. In connection with the Department of Mines must be mentioned gratefully the names of Dr. Charles Camsell, Deputy Minister, of Mr. John McLeish, Director Mines Branch (who has courteously given permission to publish certain results that were to appear as a Mines Branch Bulletin), of Mr. B. F. Haanel, Chief Engineer, Division of Fuels, and of Mr. Ross Gilmore, all of whom have aided this work in many ways.

The next acknowledgment is to the American Bureau of Mines, Washington, and with the Bureau can be coupled the names of Mr. Foster Bain, Director, — Mr. O. P. Hood, Chief Mechanical Engineer, — and Mr. W. W. Odell, Fuel Engineer.

At a time when the Board was compelled to abandon completely its own carbonizers on account of inability to render them commercial, the American Bureau very kindly consented to act as the Board's consulting engineers in the exploration and further development of the Hood-Odell oven which had been devised by Messrs. Hood and Odell and by Dean Babcock a short time previously. During the year that has elapsed since that time, the relationship between the Bureau and the Board has been of the most friendly and helpful nature; and the

record of the work done in Canada by the Board, in the further development of the Hood-Odell retort, would not be complete without a cordial expression of the Board's deep obligation to the American Bureau and to the three officials named.

Among the first authorities consulted by the Board upon its constitution in 1918, was Dean E. J. Babcock, College of Engineering University of North Dakota. From that time onward Dean Babcock has shown himself uniformly helpful and willing at all times to co-operate both by advice and by courteously giving the Board permission to make trial briquetting runs at Grand Forks and at Hebron. Of this obligation to Dean Babcock, the Board is conscious and desires to record its very sincere thanks and appreciation.

In order to make the perusal somewhat easier for the non-technical reader, a very brief glossary of some terms frequently used in this report, appears on page 101.

SECTION I.

HISTORICAL ASPECT

CONTENTS

Coal Resources of world, of Western Canada, Ratio of lignite to total coal deposits, Fuel situation brought on by Great War, Fuel problem only one of many research problems, Creation of Research Council, Appointment of Fuel Committee, Consultation and co-operation of Department of Mines and of Commission of Conservation, Report of R.C. Fuel Committee, Action of Dominion Government, Tripartite agreement, The Lignite Utilization Board an established entity.

The fundamental reason for the creation and subsequent work of the Lignite Utilization Board lies in the nature and relation of the coal reserves of Canada to the national requirements.

An inspection of Fig. 1, reveals the fact that the lignite reserves constitute the major part of Canada's coal measures, indicates also the amounts of all classes of Canadian coals, and compares them with the reserves of the United States and of the whole world.

COAL RESERVES			
RESERVES IN MILLIONS OF SHORT TONS (2000 LBS.)			
CLASS	CANADA	UNITED STATES	WHOLE WORLD
CLASS "A" ANTHRACITE OR ALLIED COALS	2 380	21 692	547 524
CLASSES "B & C" BITUMINOUS COALS	312 593	2 154 984	4 201 044
CLASS "D" SUB-BITUMINOUS COALS & LIGNITE	1 043 192	2 053 524	3 303 535
GRAND TOTAL	1 358 165	4 230 200	8 052 103

SPECIAL ANALYSIS OF CANADIAN RESERVES				
Class		EASTERN	WESTERN	TOTAL
A	ACTUAL		745	
	PROBABLE		1 635	
	TOTAL		2 380	2 380
B & C	ACTUAL	2 411	29 723	
	PROBABLE	8 466	271 993	
	TOTAL	10 877	301 716	312 593
D	ACTUAL		422 234	
	PROBABLE	28	620 930	
	TOTAL	28	1043 164	1,043,192
				1 358 165

UNITED STATES POSSESSES 52% OF WORLD RESERVES
CANADA " 16% " " "
OF CANADA'S RESOURCES 77% ARE IN FORM OF SUB-BITUMINOUS AND LIGNITE COALS CLASS "D"

NOTE:- These figures are taken from Coal Reserves of World
By McInnes, Dowling & Leach

FIGURE 1

In their natural raw state most of the low grade lignitic fuels are unsuitable for widespread domestic use, because, for one reason, the moisture content of the average freshly mined sample from the Souris field is about 35%. If shipped immediately, freight charges must be paid therefore on thirty-five tons of water for every one hundred tons of coal loaded in cars. In addition, when dried, lignite will disintegrate and slack off to a mixture of small lumps and dust, making it next to impossible to use in domestic heaters. It is therefore seen that raw lignite cannot be shipped economically, — it is quite difficult to use in domestic furnaces unless very fresh, — it cannot be stored for a long period, — and it possesses other objectional qualities. As shown in the figure about 77% however of Canada's coal resources are in the form of lignitic and sub-bituminous coals. It is inconceivable that such a vast natural resource should be allowed to remain per-

manently only partially developed. This national economic problem must, therefore, be solved somehow, sometime, by some agency.

In the pre war years there was perhaps an academic realization of the situation, but no action was planned on a large scale, and any semi-commercial ventures, conspicuous for their stock selling ability, had been marked by utter failure on the technical sides. With the war and rise in fuel prices, a new situation arose in which actual national need for fuel became for the first time a powerful stimulus. One of the results of this situation was the creation of the Lignite Utilization Board of which this report traces the origin, development, and accomplishments.

By the close of 1915 all responsible leaders of civil opinion had come to the conclusion, long held by the military, that the allied cause would only be successful by the acceptation of a very long and bitter war. The earlier hopes of a short decisive conflict had given place to the sober determination that, be the cost what it might, victory was essential if our civilization as we knew it was to survive.

The Governments of the allied powers were at that time not slow to recognize the decisive aid that science could contribute to the solution of their economic problems. During the year and a half that the war had run, both military and civil leaders had learned to depend in an increasing degree on the extraordinary assistance that science had contributed to the invention, development, and perfecting of the implements of war, and it did not require very much stretch of the imagination to convince those same leaders that only in science could the no less pressing problems of the economic stability of their peoples be solved. It was thus to scientific men that the civil leaders of all the governments of the world, during the years of 1915 and 1916, turned for aid in the development, to the greatest degree, of natural resources in order that the industrial and economic structures of their respective countries could withstand the shock incident to the termination of the war, and to provide those sources of wealth by which the governments could pay for the conflict. The British, French, American, and Japanese governments appointed during this time scientific bodies under various names, and the Canadian Government in November 1916 created by Order-in-Council, an Honorary Advisory Council for Scientific and Industrial Research.*

Among the objectives of the Research Council entrusted to them by specific direction of the Chairman of the Research Committee of the Privy Council of Canada was the following:—

> "To make a scientific study of our common unused resources, "the waste and by-products of our farms, forests, fisheries "and industries, with a view to their utilization in new or "subsidiary processes of manufacture and thus contributing "to the wealth and employment of our people."

As it is obvious that, among the great 'unused resources' fuel for both domestic heating and power is of the very highest importance,

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*For a description of the founding and early work of the Research Council see 1st annual report of its Chairman.

the Research Council upon its constitution in November 1916, appointed a fuel Committee composed of the following:—

R. A. ROSS, E.E., D.Sc., M.E.I.C., Consulting Engineer, Montreal, Convenor.

F. D. ADAMS, Sc.D., LL.D., F.R.S., Dean, Faculty of Applied Science, McGill University.

W. C. MURRAY, M.A., LL.D., F.R.S.C., President, University of Saskatchewan.

A. S. MACKENZIE, Ph.D., D.C.L., LL.D., F.R.S.C., President, Dalhousie University.

Both the Council as a whole and the Fuel Committee realized that the general fuel problem of Canada was too large an undertaking to be attacked by a body with such limited powers and resources as the Research Council, but felt at the same time that the solution of the domestic* fuel problem of the Canadian West might be brought appreciably nearer if attention were concentrated upon it.

From a glance at the figures in Figure 1, P. 18, it is seen that Canada is the second greatest coal nation in the world from the point of view of reserves; and yet for years Canada had been a coal importing country — roughly half of her requirements having been imported from the United States. The economic loss to Canada of such a situation was of course obvious.

Another glance at Figure 1. will show that, while Canada is wealthy almost beyond belief in her coal reserves, yet about 77% of these reserves are in the forms of sub-bituminous and lignitic coals. This made it clear to the members of the Fuel Committee that if these reserves were to be of actual economic value to Canada, in the near future, some method for their utilization would have to be developed. In other words, these immense reserves of potential wealth only become of benefit to the country when they can be marketed and used profitably.

In order to understand clearly the development of this work, it is also necessary to glance for a moment at the attitude of the general public at that time toward the use of these low grade bituminous and lignitic coals. For domestic heating the public in two Prairie Provinces had become accustomed to American anthracite, the price of which reached a peak in Eastern Saskatchewan, where however there are almost unlimited quantities of lignite. For power purposes the demand had been for high grade Alberta or American bituminous coals. Lignite in its raw state was not considered acceptable under any circumstances for domestic heating with the possible exception of a few cases in close proximity to the mine mouth. Under these circumstances this general fuel area was considered to be a logical point of attack.

This very brief outline of the salient features surrounding the problem, will convey an idea of the situation which the Fuel Com-

*The term "domestic" as used in this report in reference to fuel means 'for domiciliary use' and not 'Canadian' unless the context clearly demands the latter meaning.

mittee found, upon the inception of their work. After making a number of preliminary studies they decided that the work could be advanced most quickly and surely by a pooling of the ideas, views and suggestions of those Government bodies most intimately concerned with the fuel problem of the Dominion. To that end the Chairman of the Committee called a meeting of representatives of the Research Council, the Department of Mines, and the Commission of Conservation. This conference was held on Feb. 13th, 1917, and may be looked upon as the seed from which has sprung the subsequent national work on lignites and their utilization.

At the meeting the bearing and relationships of the various factors affecting a development of the western lignites were thoroughly canvassed, and a unanimous decision was reached to pursue immediately three separate lines of enquiry:

(*a*) To investigate immediately the chemical and physical properties of the Souris lignites, and of their possible by-products.

(*b*) To investigate the mining and economic conditions of Southern Saskatchewan.

(*c*) To investigate the commercial practice and commercial development of lignites and briquetting to date.

The results of these three separate investigations must now be recorded in a few short notes.

(*a*) At the conference of Feb. 13, 1917, the officials of the Mines Branch agreed to undertake this investigation in their own laboratories at Ottawa, but before actually initiating the research, the officials had to adopt oue of two contrasting policies:

(i) To undertake a research on as large a scale as possible, and to study the products and by-products.

(ii) To undertake a research on a very small scale in order to make absolutely certain that all the variable factors connected with carbonizing could be placed under complete and measurable control.

Note.—With the adoption of either of the above policies, research work on briquetting was to be undertaken subsequent to the work on carbonizing.

In favour of plan (i) it was urged that,—the results obtained would be more likely to be in line with subsequent commercial development, the large scale run would give more accurate figures on by-products, and the whole experiment would serve as a very useful preliminary operating test on whatever type of retort might be used in the research. Against this, however, the officials were faced with the problem that, irrespective of the retort adopted, the control would not be sufficiently accurate scientifically to fix beyond peradventure the influence on the product and on the by-products of all possible variables.

Moreover it would only have been feasible to experiment with one, or possibly two, carbonizers. The results would have been results with these carbonizers, not results of carbonization; and if the choice of carbonizer proved unlucky (as it easily might have

done at that time when so little was known on the subject) the value of the results would not have been commensurate with the considerable cost of the work. Under these circumstances it was decided to initiate the work on a very small scale, fix the optimum conditions for production of fuel and of certain by-products, and then gradually enlarge the scale of the work under the determined conditions for maximum results. The research was then prosecuted vigourously and a preliminary report appeared in May 1917, as a communication to the Royal Society of Canada* from Messrs. Stansfield and Gilmore.

(*b*) The research into the mining conditions of Southern Saskatchewan was undertaken by Mr. W. J. Dick, the Mining Engineer of the Commission of Conservation, who made a thorough study of the field, and his results appeared in October 1917 as a report of the Commission of Conservation under the title of "Carbonizing and Briquetting of Lignite — Economic Possibilities".

(*c*) The investigation into the commercial practice and commercial development of lignites was undertaken by Mr. B. F. Haanel, Chief Engineer of the Fuels and Fuel Testing Division of the Department of Mines. Mr. Haanel made a tour of the important American and Canadian points connected with the briquetting and carbonizing industries, and presented a report on same with recommendations. This report, dated Ottawa, April 25th, 1917, appears as appendix No. 15, and on perusal it will be noted that Mr. Haanel recommended that the best solution for the problem was to choose some qualified commercial firm, and entrust them entirely with the carrying out of the work. In the subsequent work of the Board every endeavour was made to get all such firms to quote on the several contracts for the Board's requirements.

The Fuel Committee of the Research Council drew up a preliminary Progress Report, and presented the same to Council on February 17th, 1917.

A second report which subsequently proved to be nearly in its final form was prepared after an intensive survey had been made of the conditions disclosed by the special investigations mentioned in the previous paragraphs. This report was tabled on June 8th, 1917, and was adopted by the Council. The matter and recommendations in the report can be judged by their subsequent publication as "The Briquetting of Lignites" by R. A. Ross† — being report No. 1 of the Research Council, Ottawa. It is thus seen that the course of action recommended by the Fuel Committee of the Research Council was prepared, recommended, and adopted only after obtaining the concensus of opinion of all the interested Government departments. The original recommendations did not go into matters of detail as to how the plant should be erected or what special researches should be made, but

*See "The Carbonization of Lignites" by E. Stansfield and R. Gilmore, Part 1, Transactions Royal Society of Canada, 1917.

†This report was not issued to the public until the summer of 1918. Just before its publication, Messrs Stansfield and Gilmore had presented to the R.S.C. a further report on the investigatory work originally agreed upon. See Stansfield and Gilmore — "Carbonization of Lignites" Part II, Trans. Royal Society of Canada, 1918.

were limited to the broad principle accepted by all that the carbonizing and briquetting process appeared well worthy of a commercial demonstration.

The question next arose as to the best method of carrying into effect the recommendations of the report. Neither then nor at any other time did the Research Council contemplate carrying out the project under its own aegis. It was their feeling that the work should be developed by the Department of Mines, and informal discussions were held from time to time with the officials of that department who expressed their sympathy with the idea. When, however, the Federal Government was approached, they took the stand that as the matter was one which concerned the West intimately, it would be desirable for the Western Governments to contribute some share of the expense involved. The Research Council felt that this point was not unreasonable, and therefore representatives of the Council visited Winnipeg and Regina in the summer of 1917 with a view to interesting the respective Provincial Governments, and if possible getting them committed to some participation in the venture. This mission was successful, but each of the Western Provinces was strongly of the opinion that it would be inadvisable to contribute money to be spent by a Federal Department. They, therefore, suggested that the simplest plan would be to create an independent commission or board composed of direct representatives of the participating Governments which board would have charge of the whole matter. The Research Council were agreeable to this, and upon the return of the Council's representatives, conversations were again opened with the Federal Government looking to the formation and financing of such a commission.

The Federal Government finally took definite action upon these proposals by passing an Order-in-Council No. 643, dated March 20th, 1918. By the terms of this Order-in-Council, appearing as appendix No. 1, the Privy Council recommended that the Minister of Mines negotiate an agreement with the two Provinces to implement the understanding reached by the representatives of the three Governments. By the terms of this agreement dated July 20th 1918, the text of which appears as appendix No. 2, the Federal Government, the Saskatchewan Government and the Manitoba Government undertook to provide the sum of $400,000. apportioned between them in the ratio of one-half, one-quarter, and one-quarter respectively. The agreement also provided for the method of obtaining money, the location of the plant, responsibility and creation of the Lignite Utilization Board, the fact that no member of the Board was to be paid, method of filling vacancies in the Board, minimum number for a quorum, auditing, and method of holding trust property. By the conclusion of this agreement the Federal Government paved the way for the formal creation of a Lignite Utilization Board, and on the 22nd of August, 1918, the Privy Council by Order-in-Council P.C. 2064, — copy of which appears as appendix No. 3 — actually appointed the members of the said Board as follows:

R. A. ROSS, Esq., Montreal, *Chairman.*
J. M. LEAMY, Esq., Winnipeg.
Hon. J. A. SHEPPARD, Moose Jaw.

The appointments of Messrs. Leamy and Sheppard were made by the Federal Government upon the nominations of the Governments of the Provinces of Manitoba and Saskatchewan respectively.

The Lignite Board was thus constituted under Dominion Order-in-Council, incorporated with practically the same powers as a limited company. They could sue and be sued, they could hold property in their own name in trust for the Crown, and they were to have their own resources in the bank. Their legal status is outlined clearly in an opinion from A. Chase Casgrain, K.C., dated September 17, 1918, appearing as appendix No. 4.

With the creation of the Lignite Board as a separate unit or corporation, this section closes. But such a separate status clearly implies the corollary of special responsibilities. After October 1st, 1918, the Research Council withdraw from any participation whatever in the control of the work. Their function of promoting the project had been completely discharged, and from that date onward the whole responsibility for the conduct of the enterprise rested solely upon the shoulders of the Lignite Utilization Board. This condition obtained until January 1923, when a new order was inaugurated to which reference is made in Section VI.

SECTION II.

PERIOD OF TRANSITION

Oct. 1918 to Feb. 1919

CONTENTS

On September 20, 1918, Lesslie R. Thomson, previously Secretary of the Research Council, was appointed Secretary, and early in October, R. DeL. French was appointed Mechanical Engineer. Within a few days the Chairman had concluded with the Deputy Minister, Department of Mines, an arrangement for the transfer to the staff of the Lignite Utilization Board of Edgar Stansfield as Chemical Engineer. Mr. Stansfield had been, as mentioned in Section 1, the Mines Branch Official in direct charge of the research work on lignite. The professional records of each of these three engineers together with those of other members of the staff are submitted in appendix No. 34 of this report.

The Board opened its office in Montreal on October 1st, 1918, and immediately issued a small circular in order to inform the public of its business status and commercial objectives. This circular appears as appendix No. 35.

The first two meetings of the Board were held in Montreal on September 16th and September 20th, 1918, at which general plans for carrying on the investigation were discussed. As the war was still raging, any actual investigation by the Board's representatives of European practice was out of the question. Under such circumstances the problem had to be solved by the processes, methods, and apparatus, developed on this continent. At the second meeting, therefore, a programme was adopted as follows:

Programme	*Time Allotted*
(a) To digest and index as quickly as possible all the information, suggestions, requests for assistance, inventors' statements, and patent claims in connection with lignite and its utilization, that had been gradually accumulating in the files of the Research Council.	For (a) and (b) 6 months
(b) To make a personal investigation of all lignite carbonizing and briquetting plants in the U. S. and Canada, to examine all those coal treating and briquetting plants in the U. S. and Canada from which valuable information might reasonably be expected.	

(c)	As a result of the information gained in (a) and (b) to either buy, or design and construct, a carbonizing and briquetting plant at some point in the general Souris field.	12 months
(d)	To operate the plant for a period of 6 months during which time operating difficulties could be smoothed out, accurate operating control could be established, and reliable costs obtained.	For (d) and (e) 6 months.
(e)	To then report to the supporting governments on all of the foregoing with the hope of inducing large private capital to embark on the matter as a commercial venture.	In all 2 years.

The months of October and November were given up to preparing a digest of the written material already referred to. It was divided first into 3 groups:—good, uncertain, and useless. Into the first group were placed all those matters that seemed sound and undoubtedly worthy of future study. Into the second were placed those of which the Board was less hopeful, but which could not be neglected. Into the last group were placed those suggestions and processes that were evidently valueless. Correspondence was opened up with all those represented in groups one and two, and (where possible) interviews were arranged to take place during the investigatory trip.

Concurrently with the study of the above mentioned matters, plans were made for the investigatory trip mentioned in (b). Permission had to be secured from responsible officers of the plants of which the Board desired to make inspections. Letters of introduction for the Board's representatives were obtained to many leading American officials. Schedules were prepared — all in order that time might be saved during the actual trip.

The outstanding fact at that time was that the Board expected confidently, as a result of much of the current printed information and reports, that lignite carbonizing apparatus had definitely passed the experimental stage, and was all but commercialized. The idea was further supported (inferentially of course) by the well-known fact that European practice on brown coals was thoroughly commercial. In other words, in the light of German and Bohemian success, the degree of development claimed or supported by writers and talkers on this side of the Atlantic seemed not unreasonable.

It is seen therefore that the Board then hoped that, as soon as the investigatory trip was concluded, its duty would be discharged by recommending for adoption the best oven from a field of perhaps three or four suitable ones, or that such and such a process would be suitable commercially provided certain changes were made in order to allow it to conform to the peculiar characteristics of lignite. In this hope they were to be profoundly disappointed.

On November 11th, 1918, Messrs. French and Stansfield left Montreal for the investigatory tour, during which they visited the following cities, — in most of which investigations were made.

New York, N. Y.	Pittsburgh, Pa.
Trenton, N. J.	Vancouver, B. C.
Newark, N. J.	Ioco, B. C.
Philadelphia, Pa.	Port Mann, B. C.
Lansford, Pa.	Bankhead, Alta.
Wilkes-Barre, Pa.	Medicine Hat, Alta.
Scranton, Pa.	Regina, Sask.
Dickson City, Pa.	Saskatoon, Sask.
Harrisburg, Pa.	Moose Jaw, Sask.
Washington, D. C.	Estevan, Sask.
Norfolk, Va.	Bienfait, Sask.
Parrott, Va.	Winnipeg, Man.
Louisville, Ky.	Grand Forks, N. D.
Champaign, Ill.	Duluth, Minn.
Chicago, Ill.	Superior, Wis.
Milwaukee, Wis.	Sault Ste. Marie, Ont.
Kansas City, Mo.	Sarnia, Ont.
Denver, Colo.	Detroit, Mich.
Seattle, Wash.	London, Ont.
Renton, Wash.	Toronto, Ont.

It will be noted that no visit was made to Hebron where the University of North Dakota maintained a briquette plant for the treatment of lignites. As the plant was being completely revised at that time, Dean Babcock suggested that nothing could be gained by visiting it. For this reason the inspection of that plant was omitted.

The Board's representatives returned to Montreal on Jan. 11th, 1919, and immediately set about the preparation of their report. While this was being written, a verbal statement was submitted to the Chairman outlining their proposed findings and also giving details of the fuel situation in the Canadian West. Among other matters disclosed by the investigation was the apparent marked decrease in the consumption in the West of imported American anthracite, — the increase in the consumption of Alberta coals, — and the alleged use of raw Souris lignites in certain furnaces and self-feeders originally designed to burn anthracite. If the last mentioned point were true, then it was obvious that the Board's work would be unnecessary. If owing to war pressure, methods had been devised successfully to burn these low grade fuels, with all their disadvantages, in a manner satisfactory to the householder, then why spend money on the development of an expensive process? It was felt that the quickest way to get the real facts of the case was to send French to the West immediately to look into and report upon that one specific question.

This was done, and French returned to Montreal about the beginning of February. He prepared at once a report on these matters, which appears as appendix No. 36. It can be summarized briefly as follows:

1. The large increase in the use of Alberta coals had been brought about by a campaign organized by the provincial fuel administrators during the preceding summer.

2. It was highly probable that the Alberta operators would retain a considerable proportion of the market they had gained.
3. No reliable information could be obtained whatever on the alleged successful use of the very low grade lignites in their raw state in domestic heaters.

The next step obviously was to lay the whole situation before the meeting of the Board. The third meeting of the Board was held on February 10th, 1919, and was attended by all three members.

The two most important matters presented to the meeting were: the verbal report by Messrs. French and Stansfield on their long tour, and the final report of French on his investigation regarding the uses of Western coals, and on the development, if any, of the use in their raw state of Souris lignites. Reference to each of these reports has just been made.

As a result of French's report the Board decided to continue its work. The text of the report of the long tour, dated Feb. 15th, 1919 appears as appendix No. 16, and it is only necessary in this brief review to call attention to its salient features. The condensed statements and recommendations were that:—

i) The present state of the art of carbonizing lignite did not warrant the Lignite Board in erecting a plant in the immediate future.

ii) The present state of the art of briquetting lignite did not warrant the Board in erecting immediately the proposed demonstration plant.

iii) That a large programme of experimentation be embarked upon immediately.

It now remains to present clearly the specific matters of research recommended by Messrs. French and Stansfield and accepted by the Board as an immediate programme in order to carry into effect the terms of the report. These points covered the following:—

Storage: Under this head investigations were recommended regarding weathering and natural dehydration.

Carbonization: Under this head the heat of carbonization, the rate of carbonization and the atmosphere during carbonization, and the initiation of research on a new retort of which the principle had been devised during the preceding few weeks.

Briquetting: Under this head the suitability of different chars was to be investigated, differentiated both as to degree of carbonization and screen analysis; availability of certain binders; quantity of same necessary; and the utility of different types of mixers; heat treatment of briquettes, and a testing of same.

A fuller digest of these tests, and a memo on each of the expected results appears as appendix No. 37. Also in Fig. 2 is shown a graphical presentation of the then known conditions in regard to the general process of making a carbonized lignite briquette. To illustrate this, three elementary flow sheets are presented, in each of which is shown

clearly what steps of the process were presently commercial, and those which needed considerable research.

Before closing this section it is interesting to note that at this time also the Board laid down a simple formula not only as a guide to its own staff when dealing with matters coming before them, but also to serve as an indication to the public of the attitude the Board were adopting toward the general question of full scale construction and operation. This formula was "Not one dollar for capital equipment until small scale tests proved practicability". The Board adopted this conservative attitude in spite of strong public pressure, and has never had occasion to regret its decision in this regard.

The next section will describe the conduct of these researches.

SECTION III.

PERIOD OF FUNDAMENTAL RESEARCH

Feb. 1919 to May 1920

CONTENTS

Relation of experiments to original objective, Arrangement with Mines Branch, Ottawa, and Organization set up, Equipment, Laboratory, Progress on carbonizers, Special carbonizer report by E. Stansfield, Decision to build large plant, Reasons therefor, Western trip and consultations, Fourth meeting of Board, Delegation of authority to Chairman and Secretary, Site and site negotiations.

At the meeting referred to above, the Board had committed itself to fundamental investigation only after a very careful weighing of the whole technical and commercial situation and the general atmosphere surrounding such a public project. On the one hand there was the public pressure then beginning to be noticeable and quite articulate in such newspaper captions as "Build at Once", "Show Results", "Get Action" and other similar remarks, while on the other hand there was that academic tendency, so often present in scientific research, to accept willingly enough the proposition that as the work was, in its last analysis, purely experimental, speed was unimportant and perhaps prejudicial to results. These two views may be regarded as the Scylla and Charybdis between which the Board has ever since attempted to steer, and in doing so has noted quite clearly that not only have the lateral limits of the route been very dangerous, but the length of the channel itself has been far greater than anticipated. The Board wishes therefore to record the fact that the large experimental programme to be described in this section was undertaken with a clear and steady view of its relation to the final objective originally adopted — the commercial demonstration of the carbonizing and briquetting process.

As a result of the decision made at the meeting on February 10th, 1919, it became necessary to set up at some point a complete experimental plant along approved lines. Two locations were considered for this laboratory, Montreal and Ottawa. In favour of the former was the fact that the laboratory would be in close proximity to the Head Office in Montreal, and thus allow the research staff and the other engineers to be in more intimate contact than would be possible if the laboratory were elsewhere. Against the erection of the laboratory in Montreal could be urged the great expense entailed for buildings and equipment, some of which would be a complete loss upon the conclusion of the Board's work in Bienfait. On the other hand, the equipping of a laboratory in Ottawa, though naturally involving increased difficulty of communication due to the separation of the staffs in the two places, would mean a comparatively small capital expenditure (due to cooperation of Department of Mines), and also that any equipment not required by the Board at the conclusion of its labours, would be usefully located and available for the use of the Mines Branch. In many other ways, too, the desirability of the Ottawa location became evident. For example, technical supervision would be easier, for not a few chemists, already somewhat familiar with

carbonization investigations, were available for consultation. The decision, therefore, was reached to establish the necessary laboratory in Ottawa. During the few weeks preceding the meeting, this action had been anticipated, and informal discussions had been taking place between Edgar Stansfield and the other officers of the Mines Branch as to the way in which the relationships between the two bodies and their respective staffs could be organized and recorded in the event of such a plant being located in Ottawa. To that end a written understanding was prepared under date of January 18th, 1919, which received the approval of both the Board and the officers of the Mines Branch, the text of which appears as appendix No. 5 of this report. It is sufficient to note here that Stansfield was to retain general supervision of the fuel testing work of the Mines Branch, as heretofore, and at the same time have charge of the work for the L. U. B.

The Board thereupon immediately set to work to purchase equipment to carry on the tests. It will not be necessary to note in this report the detailed purchases but specific mention should be made of one practically new Mashek Y-1 briquetting roll press (the smallest of the commercial sized presses) valued at $1,450.00 for the sum of $310 cash. A small steam jacketed mixer also was purchased. A large mixing plate was manufactured by the Board, and the usual auxiliary apparatus was acquired. The total capital cost of the laboratory and equipment was $4,963.75, and the layout of the laboratory is shown in Fig. 3 As soon as completed it was insured by the Board for the sum of $3,300 for the year 1919-1920, and for $4,000 for the year 1920-1921.

The summer and early autumn of the year 1919 were given up entirely to experimental work in Ottawa, and to the preparation of tentative layouts and designs in Montreal. It seems desirable to note briefly the result of the work in the body of this report, and insert in the appendices the mass of detail which is of permanent value from a scientific point of view.

It has been noted that the two main researches were conducted on carbonizing and briquetting. Those on carbonizing were concluded about November 1920, with subsidiary research going on until 1921, while the briquetting researches were continued well into 1921.

The progress made in carbonizing by the Lignite Utilization Board during 1919 and afterwards, cannot be dissociated from the immense amount of work done by the Department of Mines, both previously and subsequently to the creation of the Board. In particular Stansfield, Gilmore, Strong, and to a less degree, Nicholls, were for some time making extensive researches into the quality and characteristics of Canadian lignites. These researches were embodied in communications presented to the Royal Society of Canada (cit. loc. q. v.) the general drift of which was that the by-products either estimated or apparently obtained by other investigators could not be realized by the Canadian Department officers. This was one of the deciding factors that had led French and Stansfield to bring in reports at the conclusion of their investigatory trip which cast doubt upon a great deal of the published information. It is obvious, for example, that by manipulation, the gas yield of any particular lignite can be increased very markedly, but only at the expense of the residue or of the tar.

But as the L. U. B. has always been and is now concerned primarily with the preparation of a fuel, the quantity and quality of the solid residue per unit cost were of primary importance. Coupled with this fact is the other that by-products are only of economic value when they can be marketed profitably. The Board, therefore, came to the conclusion, in order to lay down a policy and to estimate the commercial feasibility of any proposed process, that no allowance whatever should be made for the possible sale of by-products. But from the point of view of the future prospects of the industry, the Board felt that a carbonizer should be obtained or developed which would be capable of producing by-products if and when it became desirable to do so, or feasible to market them. Although, for a considerable period no hope could be placed in the production or marketing of by-products, the Board would be remiss in its duty if it developed a carbonizer that was incapable of producing them.

With the idea in mind of a by-product retort, the first thought was given to a rotary cylindrical oven. The features that commended themselves were obviously the complete separation of the gas, the simplicity of operation (no pushers or mechanical devices for discharging were required) the comparatively easy control of the heat, ability to carbonize any size of lignite — even dust —, and also that, in view of the constant agitation of the lignite in passing through the retort, it would be reasonable to expect a large output, comparable to the increased output per sq. ft. of heating surface always registered by the retort with agitation, over those with no agitation.* Against the cylindrical retort, it ultimately came to be seen that the temperature at which it would be required to run, in order to duplicate the optimum conditions for lignite char, would probably preclude the use of ordinary metals, while high temperature metals had not in 1919 reached the technical position they now possess. In any case the cost even at the present time would have been prohibitive. Also the capital costs per ton of output of those retorts concerning which the Board could get authoritative information appeared high. The last few remarks anticipate in time the decision of the Board in regard to a rotary cylindrical retort but it seems best to record the decision in this place. Some years later the Board reopened the question of rotary cylindrical retorts, and the reader is referred to Section X for a very brief description of the result.

During the latter part of their investigatory trip Stansfield and French had become seized of the idea that the processes they were observing, were designed specifically for coking coals and that when handling non-coking, non-sticky coal such as lignite, the apparatus and devices available and necessary in treating the more difficult coals would be unnecessarily costly if used for the lignites. This seemed to indicate the possibility of a marked decrease in capital charges of all kinds for a retort developed for lignite treatment only. Some time before the date of the 3rd meeting of the Board the germ of the design of a lignite carbonizer had taken root, and when the principle was brought forward at that meeting it was considered and approved. The design of the apparatus was thereupon set about with a certain amount

*In this connection see appendix No. 17, with table of approx., capacities per sq. ft. of heating surface.

of enthusiasm owing to the novelty and apparent simplicity of the principles involved. The essential principle of the new carbonizer was that of a thin steam of lignite moving comparatively rapidly over very hot inclined surfaces, the thickness of the stream to be controlled by a series of vertical baffles, the heat to be applied on the under side of the inclined surface, while the volatile matter was to be withdrawn from above. In their withdrawal, the gases would come in contact with medium temperature surfaces only, by which arrangement it was hoped to avoid on the one hand tar deposition, and on the other cracking. In order to test thoroughly the retort, two examples of it were built, one named the semi-commercial and the other the laboratory or baby. The former was made with commercial building materials such as brick, fire brick, steel, cement, etc., and possessed a capacity of about 200 lbs. of raw lignite per hour. The latter was built in the usual laboratory materials of glass, platinum, cork, etc. etc. Each of these models contributed a great deal to the knowledge of the principle and of the operation of the carbonizer. During this time successive changes were made in each until by the close of the season more or less completely successful operation had been achieved; and it was only after successful operation had been obtained with the larger retort that the Board made its decision to proceed with the western plant.

It is important to note at this point that in the very nature of the case no method existed by which gas handling or tar extraction apparatus could be tested on a small scale. In other words, while information of very great value could be obtained by building and testing models of carbonizing apparatus, models of gas handling or tar extraction devices would be almost useless. Therefore during the season of 1919 the gas from the semi-commercial retort was simply bled into the air and burned, while the gas handling equipment of the baby carbonizer was constructed of condensers and bottles in the ordinary methods of a laboratory. The Board therefore at this time took the attitude that the handling of the gas, and the tar extraction, must await the erection of full scale apparatus in Bienfait.

Stansfield in appendix No. 18 describes minutely the development of his retort, and goes thoroughly into the question of heat required for carbonization.

By October, 1919, enough success had been attained apparently with the Ottawa experiments to warrant the Board in announcing publicly its intention to proceed at the earliest date with the erection of the main plant. The reasons for this are elaborated more fully in the appendices, but should be recorded here in a word or two. The new carbonizer on which the hopes of the Board were centred had proved to be on the whole successful, that is to say, the principle had apparently proven sound (this remark for reasons mentioned above on this same page does not apply to gas handling apparatus). The output capacity per square foot of heating surface, and the output per hundred dollars of estimated capital cost, were both very much higher than in any retorts of which the Board had knowledge. In other words, one essential of the problem, — economy — had apparently been achieved. Without apparent large economy

it would have been folly to move forward, but the comparative results seemed to indicate that the Board had brought the carbonizer development to a successful conclusion so far as experiments on that scale could prove anything. They felt justified therefore in proceeding with the erection of the full scale ovens at Bienfait.

Another reason that led the Board to feel justified in its decision to proceed with the erection of the main plant was the indication of success in the briquetting results, which however are touched upon in Section VIII. In other words, in the two main problems facing the Board, namely carbonizing and briquetting, the experimental research both on a semi-commercial scale, and on a minute laboratory scale, had indicated to all those intimately in touch with the situation the high degree of probability of success. It was only when this point had been reached that the Board made any public announcement of its decision to proceed with the construction of a full scale plant.

Having reached this point, the next obvious step was to consult the mining men in the field, and others practically interested in the development and marketing of the lignites. The purpose of this consultation was to inform them of the tentative plans which had then been made by the Board, to ask for their criticisms of these plans, to request the benefit of their advice on many local conditions in regard to mining, housing of employees, etc., and to receive any suggestions whatever germane to the problem. As this meeting would involve the Board appearing in the West it was decided to hold also a public meeting in Winnipeg, where the interest in the project had been extraordinarily keen. The purpose of this public meeting was to inform any and all interested as to the work done to date, and to make a statement as to the future intentions of the Board. The Winnipeg public meeting was held therefore on October 6th, 1919, in the Legislative Chamber of the Parliament Buildings of Manitoba. At this meeting about fifty people were present including a number of members of the Government of Manitoba; and a great many questions were asked of the Chairman, and to these questions full replies were given.

On Wednesday, October 8th, 1919, a consultation was arranged with the mine managers and operators of the Estevan-Bienfait area. For the list of those present, and a digest of what took place the reader is referred to the minutes of this consultation appearing in appendix No. 39. Information of great value was obtained, and very careful weight was given to all the opinions expressed, owing to the feeling that existed in the minds of the Board that men so intimately connected with the field as were these managers and operators should be in a position to speak with authority.

Upon the conclusion of the consultation above referred to, and after absorbing the information obtained, the 4th meeting of the Lignite Utilization Board was held on Thursday, October 9th, 1919. At this meeting decisions of great importance were made. These decisions covered among other things the following topics; right of the Board's employees in patents; letting of contracts; site and site negotiations.

The question of patents which might be obtained by the Board's employees had been discussed at some length informally on previous

occasions, and as it became apparent that the Board as such was not able under Canadian law to take out patents in its own name, it was necessary to have such patents as might be sought, taken out in the name of some one specific person. Under these circumstances the Board decided that every patent applied for should be taken out in the name of one member of the staff, and that an agreement be entered into immediately with each one of them in order to arrange beforehand as to the rights of the respective parties to any of the benefits that might enure.

A copy of this standard agreement, which was signed by each member of the staff, appears as appendix No. 6. These agreements provided:—

a) That all interest in any Canadian Patent should be assigned to the Board.
b) The Board shall pay all expenses in connection with those Canadian patents, application of which they approve.
c) That the return to the inventor should be at least half of the net profit accruing on Canadian patents.
d) On foreign patents the Board pays expenses of those they desire to control, and net benefits accrue to inventor, — while all expense and gross benefits revert to inventor of those patents which the Board does not care to control.

At this meeting also it was decided to patent as quickly as possible the principle of the new carbonizer developed by Stansfield.

The next question discussed was one which affected the conduct of the Board's affairs to a very marked degree. The Chairman asked specifically whether the two Western members desired to have all contracts and business matters submitted to them for their consideration before any action could be taken by the Board. Upon discussion it became apparent that if such a course of procedure were adopted the resulting delays would increase to no small amount the time taken by the Board in each of its decisions on the various matters coming before it. Under these circumstances it was moved at the 4th meeting by Mr. J. M. Leamy and seconded by the Hon. J. A. Sheppard and **Resolved:*

> "That the Board do hereby empower R. A. Ross, Chairman, and Lesslie R. Thomson, Secretary, to sign all agreements, awards, contracts, and any other documents whatsoever, on behalf of the Lignite Utilization Board, and to do any or all other things necessary for the complete design, building, erection, and equipment of the Board's plant."

As a result of the adoption of the foregoing resolution it became inevitable that the real responsibility during the active conduct of the business of the Board rested more heavily upon the Eastern section of the organization than upon the Western. During the progress of the work the Western members were kept informed as fully and as quickly as possible, but the actual decision on each matter was taken

*Minute No. 6 of the 4th meeting of the Board, Oct. 8th, 1919.

in Montreal. As a result of the information circulated regularly to the Western members, and in accordance with their own personal observations and inquiries, it is interesting to note that at the 5th meeting of the Board held in Winnipeg, October 19th, 1921, subsequent to the completion of the plant, the following resolution was adopted, unanimously, --which indicates that the efforts of the Montreal office were, however, not unacceptable to the Western members of the Board.

> *"The Board made a general review of all its operations from the time of its establishment, and of all contracts made, expenditures authorized or incurred, work done, and payments made by and on behalf of the Board, and particularly of all contracts entered into, awards given, work done, expenditures incurred, and payments made in connection with the briquetting plant now established at Bienfait, Saskatchewan, including those relating to the plant and buildings, houses, boilers, machinery, engines, conveyors, and conveying systems, electric motors, pulverizers, briquetting equipment, dryers, water tank, fans and blowers, pumps, power installations, switchboard, gas purifying apparatus, water supply and sewage disposal, valves and piping, laboratory supplies and apparatus. It was therefore moved by the Hon. J. A. Sheppard — seconded by Mr. J. M. Leamy and

"*Resolved*

> "That the Board place on record its ratification and approval of all the foregoing items and of all actions by it or on its behalf done in connection therewith."

Upon the conclusion of the 4th meeting which as already noted was held in the West, the Board set itself to a discussion and a settlement of the question of site. It is interesting to note here that one of its first researches was directed entirely to a critical examination of the physical aspects of the general Souris area — particularly in and about Estevan. One of the early conceptions of the Board was that the plant should be located over a reasonable seam of coal in order to guarantee to itself the supply of the most essential of the raw materials in the event of the coal operators ever attempting to shut off supplies of raw lignite by charging too high a price, or by any other common action inimical to the Board's welfare. If such a seam were ever to be of value for such a purpose, its quality must necessarily be acceptable for carbonizing and briquetting purposes. It has already been pointed out frequently that it takes a little over two tons of raw lignite to supply the char for one ton of briquettes. This indicates at least a doubling of the ask content of the original lignite in the resulting briquette. Hence if the Board were to place its plant over a suitable coal seam it became necessary to know the ask content of all the lignite produced in the Souris region.

Of the men available for such sampling and investigation, there was one who by previous personal experience of the field was best qualified

*Minute No. 4 of the 5th meeting of the Board, Oct. 19, 1921.

to undertake it — Mr. Alexander MacLean of the Geological Survey and also of the geological staff of the University of Toronto. Through the courteous co-operation of the President, Sir Robert Falconer, Mr. McLean was given leave of absence for a couple of weeks in the autumn of 1918 to proceed to Estevan for the purpose of sampling each of the mines, and also to take any notes that might still be necessary in order to prepare a brief report on the geology of the region. This report, and the result of the sampling appear in appendices No. 20 and No. 19 respectively.

During the preceding summer the staff of the Board had been engaged in debating confidentially this whole question of the site, and had come to a unanimous conclusion as to the ideal location of the plant. The information requisite to reach such a decision had been furnished by the available reports on the district, by special reports kindly furnished by the M. L. & Y. Branch, Department of Interior, by information obtained from Mr. Alex. MacLean (see appendices 19 & 20) and from personal observations made by French and Stansfield upon their tour. Upon digesting all this information a conclusion had been reached which was conveyed confidentially to the Board in the report dated Oct. 1st, 1919, signed by French, Stansfield and Thomson, which report appears as appendix No. 21. This report recommended that the plant be situated half way between the two largest mining companies of the region, namely the Manitoba and Saskatchewan Coal Company and the Western Dominion Collieries. This recommended site is shown on Fig. 4. In making this recommendation the staff felt that the obvious dangers and disadvantages of the location could be safeguarded completely by a properly drawn agreement. This report was presented confidentially to the Board for their consideration, but no decision was reached until after the meeting held with the operators and after the general inspection of the field. The actual decision was reached at the 4th meeting of the Board held on October 9th, 1919, when it was decided that the report should be accepted, and that the referred to site should be obtained provided the Board's interests could be maintained in reference to the four following points:

(a) Freight service on existing spurs.

(b) Supply of water from existing pipeline.

(c) Special sidings to be built by each of the companies to the Board's site.

(d) The sale in fee simple to the Board of the requisite amount of land together with a guarantee against any damages due to subsidence.

Having reached such a decision the Board opened up negotiations with Mr. Hugh Sutherland, President of the Western Dominion Collieries, the owners of the site preferred, and with Sir Daniel McMillan and Senator Robert Watson representing the Manitoba & Saskatchewan Coal Company — which company owned the pumping station and pipeline to the Souris River.

The preliminary discussion brought out the following facts:

(i) The Western Dominion Collieries would not consent to sell but would be willing to lease under certain conditions.

(ii) The bond holders of the Western Dominion Collieries would have to be consulted.

(iii) That if a lease were drawn, then all the four organizations interested, (L. U. B., W. D. C., M. & S., & Trustees Corp., London) would have to be parties to the agreement.

Upon consideration of the foregoing the Board came to the conclusion that, if the site suggested were to be adopted, it would be necessary to have the lease agreement cover a very wide field of common or engaging interests. The Board therefore had to decide whether to forego their hope of what they regarded as the most favourable location, all things considered, to accept another site with a clear title in fee simple, or to adhere to their own selection involving as it did the acceptance of a rather complicated agreement. It was finally decided that the latter alternative was the better, especially in view of the power that could probably be wielded by a body of the nature of the Lignite Utilization Board with its governmental connection and engaged in the development of a public need. The Board believed that it would be possible to obtain the site, obtain the necessary services of coal, water, etc., and at the same time safeguard itself from the charge of being in complete control of the two largest companies of the district. In addition to safeguarding the Board's direct interests, it was felt very keenly that the value of its own equity could only be maintained by a perfectly free right to sell, sublet, or assign in any way whatsoever without let or hindrance on the part of either the neighbouring Company, (the Manitoba & Saskatchewan Company) or of the lessor, (the Western Dominion Collieries). In other words, if the Board did not or could not posses this free right of disposal, it was patent that any value created by its efforts in or on the demised premises was not a marketable asset. Hence on one or two occasions during the long, tedious, and occasionally acrimonious discussions, the negotiations were nearly broken off by the Board standing firm for the inclusion of the clause that appears in the final agreement as clause No. 7.

During the discussion with Mr. Hugh Sutherland and Senator Watson, already mentioned, the preliminary broad outlines of an agreement were reached; but the detailed negotiations covering these points extended all through that winter. In addition the Bond holders of the Western Dominion Collieries, the Trustees Corporation, Limited, London, had to be not only consulted but included as a party to the lease agreement. This document was finally concluded upon May 1st, 1920 when the lawyers representing respectively the various parties exchanged undertakings on behalf of their respective clients for the signatures, if and when the necessary surveys could be completed. A copy of this lease agreement, appears as appendix No. 7 to this report. The points in the agreement to which attention should be called are as follows:

(a) That the period of the lease is 21 years and renewable for a further 20 years.

(b) Terminable at the Board's option upon a year's notice.

(c) The Board agrees to operate a plant continuously between 1st April and September 30th, which undertaking is subject, however, to delays or stoppages beyond the control of the Board.

(d) Each of the mining companies is under obligations to do switching for the Board under a reasonable remuneration.

(e) An ample supply of coal is assured at prices to be determined in open competition.

(f) The M. & S. agrees to deliver an ample amount of water for the Board's purposes with a minimum daily guarantee.

(g) Each of the companies agrees to build a railway spur at their own expense to connect the Board's plant with their own mines.

This section has traced the work of the Board from the inception of its experimental programme to a point where it had apparently been successful in prosecution of the research, and has related also how the site of the future plant was determined. The next section will deal with the questions of design and construction.

SECTION IV.

PERIOD OF DESIGN AND CONSTRUCTION OF BIENFAIT PLANT

May 1920 to Aug. 1921

CONTENTS

The last section has shown that the Ottawa experiments on carbonizers had given promise of success, — in fact they had been pushed to the utmost. No further laboratory demonstration would have been adequate for the project, or consonant with the Board's original order in Council, which required a *commercial* demonstration. Hence full scale apparatus had to be used finally to prove or disprove the whole conception, and no alternative of such conditions could ever be accepted as a final demonstration. Therefore the risks always incident to such construction ultimately had to be taken resolutely.

Before describing the design of the plant in detail, some preliminary decisions must now be recorded. These decisions included answers to the following questions: What quality of plant should be built? — Should it be flexible, — should it be built at once to full capacity or gradually as experience of parts proved correctness of design, — and finally what class of housing should be provided?

These questions will now be touched upon consecutively. The proposed capacity had already been determined by Governmental agreement — 100 tons per day of briquettes which appeared to be the smallest plant suitable for commercial demonstration. This indicated a fair sized plant, and as it was expected that the ultimate destiny of the plant would be that of a Governmental testing station for briquetting western coals, it was decided to build in a solid and permanent style. The decision was reinforced, too, by the fact that the fire hazard existing in any processing of lignite would be far higher than in an ordinary coal treating plant. The soundness of this decision is indicated by two facts. First, in spite of two or three serious fires in the early stages, no general conflagration resulted. Second, the original insurance rate was $1.25. As a result of stability of construction and of pressure exercised by the Board the rate has been reduced to 69 cents during the period of partial shut down.

A highly flexible plant with absolutely complete provision for bypassing each and every unit with provision also for complete reversal of routing would have been out of the question for financial reasons. As indicated in Section VIII, the briquetting room is partially flexible, and the installation and excess capacity of the dryers are further evidence of flexibility. This arrangement was due to the belief in 1919-20 that it might be possible to develop a market for dried lignite.

It is obvious that in the divisions of raw lignite handling, conveyors, bins, mixing, briquetting, gas handling, tar extraction, power house, sewage disposal, water supply and housing, — gradual construction

in small units would be out of the question. This leaves only two departments, drying and carbonizing, where it might have been possible to install commercially (from point of view of capital investment) one or more units, test them, and then install others gradually. In regard to dryers, scientific requirements* made it necessary to install dryers of the largest size possible if waste heat from carbonizers were to be utilized economically. Therefore 2 units of 150 tons each were provided. Coming next to the carbonizers, they were installed in three paris of two each — providing six carbonizers in all. It would certainly have been possible to install one pair, but it must be recalled the public pressure that was upon the Board to get the plant operating to its capacity; the honest conviction possessed at that time of the ability of the carbonizers to function; that it was obvious that only by constructing all the carbonizers could a considerable throughout be obtained and the process be demonstrated commercially; and that the disorganized industrial conditions of the time made deliveries most extraordinarily slow.† If then a unit construction had been adopted the Board would have to look forward to similar delays in the construction of the subsequent units if and when decided upon. Also the cost of such delays would be far more than the amount involved in the capital construction of a portion of the carbonizers, which was the real amount of money risked when taking the decision. In addition the gas handling equipment (necessary to operate even one full scale retort) could not have been tested adequately except with all retorts in operation. For these weighty reasons it was decided to take boldly the risks inevitable with such a decision, and to install the full carbonizing units in order to provide the product that was being demanded so persistently.

The completion and successful operation of the plant, would require a staff of from thirty-five to forty-five men. In no way could the Board see any suitable accommodation for the type of workmen desired. While t is true that for some of the rougher work about the yard, etc. only unskilled labour would be required, it was obvious that for the successful handling of the carbonizers, dryers, mixers, and the briquetting press, labour of a singularly intelligent character would be needed. It was difficult to suppose that such men would be content permanently with the very rough accommodation that apparently is satisfactory for the workmen in the neighbouring properties. The men on the staff of the Board would be of a superior type, and coming from other places would naturally compare the accommodation to which they had been accustomed with what they would be receiving at the L. U. B. plant unless suitable provision were made. Under these circumstances eight workmen's cottages, four cottages of a slightly larger size, two houses for manager, chemist, etc., and one boarding house for the unmarried men were erected as part of a general housing scheme. The provision of running water and simple sanitary conve-

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*In connection with heat economy it must be remembered that the Board knew from the very inception of the work that for heating the carbonizers no extravagant hopes need be entertained regarding any excess of available gas. They realized from the beginning that any exteriorly heated retort for lignite would barely provide enough lignite gas for carrying on the project.

†As an example of these deliveries it is to be noted that the carbofrax slabs for the floor of the carbonizers were ordered in April 1920 with promised delivery in July of the same year. Though every means was taken by the Board to hasten production, these slabs faithfully promised for July delivery were not delivered until March 1921.

niences in these houses has apparently raised a considerable protest, and the usual charges of extravagance, mismanagement, etc. have been levelled in a most irresponsible manner. But it is perhaps not too much to say that the success or failure of the plant might very easily have been determined by the morale of the staff. It therefore behooved the Board to make every reasonable provision for this need. It is perhaps interesting to speculate also as to the charges that would have been made against the Board had the plant proved a complete success from its inception and had no provision whatever been made to house the staff. Upon completion rentals were charged for all houses, which have produced at the rate of 2.2% per annum of the capital invested. The boarding house has of course been operated on business lines usually found in industrial plants.

In recording the foregoing decisions, and some subsequent constructional features of the plant, certain undoubted mistakes and errors are reported, and no attempt is made to hide or gloss them over. The responsibility for them is accepted fully. In doing so, however, the Board only ventures to point out one fact which, in the review of any situation is so often overlooked – that the critical analysis of all the factors of a problem that has worked itself to a conclusion by the effluxion of time seems so extraordinarily simple that even the least learned are surprised and pained that it was not obvious to those who had the responsibility of attacking it before the recorded events took place. Colloquial English has described such a situation by stating that hindsight is easier than foresight.

These then were the preliminary decisions and points that had to be weighed, discussed and decided within a comparatively short time. It is now proposed to discuss the design and construction of the plant.

Attention cannot be called too emphatically to the fact that the design of this plant was a matter of investigation and experimental research. The problem before the Board's engineers was not the building of a factory to turn out a standard commercial product by means of a well known and thoroughly developed process, but it was rather to design an experimental plant that would be devoted to the commercial demonstration of a chemical and heat controlled process never achieved successfully elsewhere on a commercial scale. In this way it was of necessity a new venture into an unexplored region. To have attained a sweeping success on the first attempt would have been just as unlikely as to have expected that the first commercial cement plant or coke oven would have been perfect on the first full scale effort in those respective industries. This point of view gives the perspective or scale by which the subsequent work described in this chapter should be viewed.

In Oct. 1919 was made the decision to undertake the main plant construction. From that time onward the Board set itself to the problem of the design of the plant buildings, the design of such apparatus as was not standardized and commercial, and to the preparation and awarding of contracts for all the main and auxiliary machinery.

The methods utilized for buying were as follows:—

All the more important purchases were covered by special specifications and contract forms. These were then advertised for tender at a

certain date. The less important ones were covered by specifications and contract forms and were mailed for tender to all the leading firms dealing in that special product. Minor purchases were undertaken by inviting prices by personal letters to those firms of which the Board had any knowledge.

By far the largest single deal undertaken was that for the construction of the plant buildings and houses, and as this contract was typical of the handling of all the more important contracts, the Board submits in appendix No. 8 copy of the actual contract, the form of which was issued to all those who tendered in response to the advertisements. In addition in Fig. 5 will be found a digest of all the bids received, and the reason for awarding the contract to Messrs. Smith Bros. & Wilson, Limited, Regina, is quite apparent.

Some question might be raised at this point as to why such a special type of contract was entered into for the construction of the plant buildings and houses. In this connection it will be recalled that during 1920 it was impossible to get any contractor to work on any contract on a lump sum basis. Under such circumstances the alternative of a cost plus contract became inevitable, but the Board viewed with considerable apprehension such a type of contract due to the rapidly advancing market both in material and labour. Under the pressure of these conditions very close attention and thought were given to the contract, and the form already referred to and illustrated in appendix No. 8 was finally adopted.

The preparation of the specifications, form of tender for the supply of boilers, steam engines, electric generators, conveyors, motors, etc., calls for no other special comment, and in appendix No. 40 will be found a digest of the contracts entered into by the Board together with time started and time finished. It is to be noted that large sums were saved by purchasing second hand, parts of the power equipment railway cars, briquette press, etc.

The contract for the construction of the buildings was signed on April 30th 1920, and completion was expected before winter set in. Owing to the extraordinary delays in the delivery of materials of all kinds, it was not until the month of August, 1921, that the Board could announce the completion of construction.

Appendix No. 22 prepared by I. F. Roche and R. A. Strong, gives in detail a complete description of the plant by departments including gas handling equipment, in order that the reader may be familiar with the whole installation.

During the construction of the plant one of the serious difficulties encountered was that of the interruption of the supply of water due to the bad state of repair in which the pipeline was found to be. It will be recalled that by the terms of the lease agreement the Manitoba & Saskatchewan Coal Company were under obligation to furnish the Board with water and that a minimum of one hundred thousand gallons per day was guaranteed. Owing to the constant breaks in the line the Manitoba & Saskatchewan Coal Company was never able to live up to this guarantee, and as the period for preliminary operation drew near the Board's Resident Engineer, I. F. Roche, grew so anxious

about the matter of water supply that the Secretary was sent to the West especially to look into that question and to arrange if possible for the immediate amelioration of very unsatisfactory conditions. At the resulting conference in Winnipeg on July 18th, 1921, the Manitoba & Saskatchewan Coal Company took the attitude that the line was beyond repair; expecially was this true for that portion below the brow of the hill. They also stated that they absolutely refused to build a new line on account of their own financial condition, unless the Lignite Utilization Board undertook some share of the cost. In rebuttal to the above the Lignite Utilization Board took the attitude that the line was not beyond repair, but agreed as a matter of grace to absorb their share of any annual charges pro rata that might be incurred by the Manitoba & Saskatchewan Coal Company in major repairs, but stated further that, until such time as the plant was operating, the Board could not and would not entertain any question of assuming capital charges that properly belonged to the Manitoba & Saskatchewan Coal Company. The Conference was adjourned till Tuesday, the 19th, when after long discussion no agreement was reached, and a further adjournment was made until Wednesday, July 20th, 1921. At this Wednesday meeting after prolonged discussion the Board compromised the matter by agreeing to a joint capital expenditure (subject to certain safeguards as to ownership) to put in a new portion of a cast iron pipeline below the hill, and to this the other parties agreed. The Secretary left Winnipeg with specific verbal assurance from the Manitoba & Saskatchewan Coal Company that the matter would be put in hand at once on the basis agreed upon. One excuse after another was however discovered by this Company for deferring action, until finally the Chairman decided to call a meeting of the Board in Winnipeg in October, 1921, and either get the signatures, or enter suit. As a result of these energetic measures the Manitoba & Saskatchewan Company signed the supplementary agreement, and construction work on the pipe line was started shortly after and completed in November 1921. As a result of this replacement of a new section of the pipe line along the road allowance, the plant has never actually been short of water, although the condition has been anything but satisfactory. Indeed it is doubtful if the line could supply the contract quantity regularly.

SECTION V.

PERIOD OF PRELIMINARY OPERATION OF STANSFIELD CARBONIZER

Sept. 1921 to Dec. 1921

CONTENTS

Operation of dryers, conveyors, briquetting press, and mixers, gas handling apparatus and carbonizers, Troubles and difficulties, Staff reports of September and November changes, Consultation in Montreal between Lignite Utilization Board and C. V. McIntire.

By the beginning of September, 1921, the construction of the plant was completed. The point toward which the Board's energies for a period of three years had been directed, was finally reached, and the period of preliminary operation, the culmination of thirty-six months of thought, planning and labour, was entered.

In putting any new plant into operation, and especially one demanding a number of separate departments or processes functioning like a chain of separate links, each dependent on the other, it is necessary to initiate operation by departments successively. During each of these separate trials the minor defects and troubles that are inevitable with new or untried machinery must be overcome, and the causes therefor removed. Thus one by one the several departments are placed gradually in smooth operating condition, and only when this point has been reached, do the engineers feel justified in attempting to link up the operation of one department or process with its neighbour, in order that there shall be absolute continuity to the movement of the commodity under production from the beginning to the end.

During the whole of the autumn of 1921, attempts to operate the carbonizers were the outstanding features of the Board's work, and as it was this process that failed so signally to meet expected results, the discussion on carbonizing will be deferred for a little in order to record the operation of other parts of the plant linked with the carbonizing.

It will be recalled that the drying equipment consisted of 2-55′ cylindrical rotary dryers built by the C. O. Bartlett & Snow Co., Cleveland, Ohio. The first attempt to operate these was made on Aug 22, 1921, with a twofold object, namely: to smooth out the incipient troubles which were sure to be encountered, and at the same time to furnish dried lignite which could be fed to the carbonizers when the latter were started. The normal method of operating these dryers was to be by the waste heat from the battery of carbonizers, but as the carbonizers were not running the auxiliary method of heating — by coal fire — was of necessity utilized. Owing to the financial stringency at that time it was not possible to purchase certain indicating instruments and thermal controls which would have to be supplied ultimately, if satisfactory continuous operation were to be attained. The first run was a failure owing to the fact that the coal in the dryers caught fire, and there was considerable trouble extinguishing it. This was a difficulty that had been apprehended from the beginning by the Board's engineers, owing to the low ignition point of lignite as compared with anthracite coal. Certain changes* were made in the direction

*For details see appendix No. 23 prepared by R. A. Strong.

of flow of heating gases, and further trials instituted which indicate that these dryers can be used for drying lignite coal, without undue risk of firing the coal which is being processed. It should be noted at this point that owing to the Board's preoccupation with carbonizer troubles no long continuous runs have been made as yet on these dryers to determine absolute efficiencies.

The power plant proved on the whole to be satisfactory. Certain minor defects developed which were corrected, but since the commencement of operation reasonable satisfaction with the powerhouse and power equipment can be reported. The only troubles that have developed have been those due to worn parts, for example: steam valves on the 100 KVA unit, piston rods on the same unit, and one or two of the valves on the 400 KVA unit, such replacements being almost inevitable when secondhand machinery is purchased in order to save money, and to expedite delivery. No success has been attained as yet in operating the two alternators in parallel. It was hoped to be able to do this, but experience to date seems to indicate that the governor on the 400 KVA unit is not sufficiently delicate for the purpose. This is, however, not a serious defect as the 400 KVA unit was designed to carry the day load alone, and the 100 KVA unit the normal operating night load.

The sewage disposal plant was placed in operation immediately upon its completion. In view of prairie conditions with lack of drainage, the system was designed to allow the effluent to run from the collecting basin by gravity into a large number of farm tile drain pipes in order that the soil might gradually absorb the water. So far this has only been partially successful, and a considerable amount of excess water finds its way to the surface of the prairie, to be carried off by natural evaporation. The net result has been to make the land to the west of the sewage disposal plant much wetter than before the plant was located there.

The tests on conveyors, machine shop, briquette cooling, storage, do not call for any special comment in this report; but incidental reference can be found to them in various appendices.

It seems logical to record the operation of the balance of the plant during the autumn of 1921, under the heads of: carbonizers, gas handling equipment, and briquetting equipment.

As the carbonizers and the gas handling equipment are so intimately connected it is difficult to separate completely the reports on these.

Carbonizers:

This section will record the tests, difficulties found, and the final failure of the Board's retorts in as simple language as possible, and leave to the various appendices, the details that are at once of interest and importance to those who will have to do with the designs of future carbonizing and briquetting plants.

The Board now had six carbonizers ready for test — Nos. 1, 3, and 5 facing the east side of the building and Nos. 2, 4, and 6, the west side. In all respects these carbonizers were identical in design, and every constructional detail embodied in them was the result of experience

gained on the semi-commercial carbonizer erected and operated in Ottawa during 1919. It is to be borne in mind also that owing to severe financial straits in which the Board found themselves at this time, it had not been possible to purchase the pyrometers and similar auxiliary recording and measuring devices that should have been on hand for these tests. During a greater part of the time when Stansfield, Strong, and Roche were giving of their very best to the solution of the operating troubles, they were badly handicapped owing to the absence of these instruments.

A gentle slow heating fire was lit in carbonizer No. 5 on September 2nd 1921, in order to heat up the carbonizer, and on Sept. 8th, the fuel oil fire was lit in the combustion chamber. At the start the upper hopper was filled with crushed coke, and as mechanical operation under these conditions was achieved, attempts were made to feed dry coal through the apparatus. The net result was failure, and the details are described in appendices Nos. 23 and 24 to which the reader is referred. The basic reasons for the troubles were not at first realized and to certain secondary causes were attributed the blame for the results. Among these causes were the Isbell-Porter regulator (which was the device supplied under the gas handling contract to regulate pressure in the gas offtake of the carbonizer) the discharge mechanism of the carbonizers themselves, the cooling devices, and the baffles. These troubles are described in the appendices mentioned and it is only necessary at this point to state that while the various troubles were important and undoubtedly contributed to the result, the causes of final failure were to be found in constructional and operating difficulties that were practically inherent in the design as developed at that date. This observation does not necessarily apply to similar designs that have been developed since 1922.

In October, changes were made in the pressure regulator, in the discharge mechanism, and in the cooling mechanism. The final payment by the Government of the extra appropriation (see section on Finance) enabled the Board to purchase pyrometers, fire fighting apparatus, etc., all of which were on hand for the next test. These various changes were made following a report dated Sept. 12th, 1921, presented by Edgar Stansfield and the resident staff, R. A. Strong and I. F. Roche. All the recommendations of this report were put into effect, and on November 1st, the second trial operations were undertaken. Unfortunately the gas pressure regulator as revised was but little improved, and a system of control by hand had to be inaugurated which proved fairly satisfactory. In later tests this difficulty of gas pressure regulation became so acute that the gas was bled into the atmosphere in order to simplify the problem. While many difficulties were experienced during this series of runs it was possible to determine more or less exactly the cause of each. The main troubles can be listed under the heads, gas control, floor and wall leakage, and the interruption of the flow of lignite, caused by the presence of fine lignite dust in the coal as charged. The presence of this dust made a considerable departure from the screen analysis that was used in Ottawa. This last specific trouble, which might be expected to be encountered when using any lignite that had been stored for some time, led to the development of a new type

of baffle, somewhat superior to the old ones, and in that way it became perhaps an advantage though quite thoroughly disguised. At the close of the November runs Stansfield, Strong and Roche prepared a report dated November 19th,* outlining the difficulties that had been encountered, and giving suggestions for remedial action, together with a further suggestion that after some more runs with the new baffles (then in course of fabrication) a round table conference be held in Montreal in order to determine future action. The report recommended that for this conference an expert in retort design be engaged to pass judgment on some of the suggestions and changes proposed. The Board agreed with all of these points, and arranged that a conference should take place in Montreal shortly before Christmas, 1921, with the stipulation that the runs suggested in the report of November 19th should be held without fail in order to determine the efficacy of the new baffles. These runs were held as agreed upon, and on the whole the results were looked upon at the time as most encouraging.

Gas Handling Apparatus.

The gas handling apparatus described in detail elsewhere cannot be said to have been given any thorough trial whatever during the autumn of 1921 owing to troubles with the regulator — which was not sufficiently sensitive for the requirements of the plant. The decision was soon reached to obviate all the troubles incident to the use of the whole gas handling apparatus, by bleeding the gas direct from the retort to the atmosphere and thus concentrate all attention solely on the carbonizers. Owing to this decision, it was impossible to make any real test on the various parts of the whole gas handling system, — and it was not until the test runs of the autumn of 1922 that the weakness of the exhauster, and some other difficulties, were disclosed. These will be mentioned again in greater detail.

Briquetting.

The first tests on the briquetting machinery were made without any load whatever merely to prove the mechanical operation of the various machines and conveyors. It appeared from these tests that the machinery was in good condition, the power adequate, and the layout fair. It remained for later tests when carbonized lignite was going through and being mixed with binder, to disclose those faults of layout which the Board soon recognized.

The first briquetting operations were made in November of 1921, using carbonized lignite from the trial runs previously described. The briquettes made on this run were of very poor quality particularly in regard to the large amount of binder found necessary to make a briquette that would hold together. Subsequent work has shown, however, that this was due to causes inherent in the initiation of any new process. The operators were not familiar with each machine; the temperature controls were inacurate, etc. etc. The net result of the runs up to that time might be summarized by saying that briquettes were made, the machinery was adequate and no reason existed for apprehending any permanent difficulty in producing briquettes when

*The general sense of this report of November 19th and the exact details of the runs of December, 1921, are covered in appendix No. 23.

conditions become stabilized and continuous. Subsequent runs with the briquetting plant were much more illuminating and much more successful, but in keeping with the desire of the Board to make a very sharp distinction between the period closing in December 1921, and that starting in January 1922, the Board will present the subsequent briquetting results in chapter VIII of this report.

Acting upon the report submitted to the Board by Stansfield, Strong and Roche, the Board called a meeting on December 21st, 1921 of the following:—

R. A. Ross.
R. DeL. French.
I. F. Roche.
R. A. Strong.
C. V. McIntire, New York, Consulting Engineer.
Lesslie R. Thomson.

At this meeting the whole technical situation was canvassed very thoroughly, each of the difficulties encountered (both operating and structural) was discussed in minute detail, and the suggested remedies for same were criticized freely. During the discussion there gradually emerged a group of remedies and changes which seemed in the opinion of all present, to combine practicability and a likelihood of achieving commercial success. Briefly these changes were:

1. The reconstruction of the floors and carbonizing chambers of three only of the carbonizers in order to test out the proposed changes thoroughly before rebuilding the remaining three retorts. To give an idea of relative suitability, three different floors systems were decided upon:—
    (a) Floor in flat tiles of carbofrax in two layers.
    (b) Floor in hollow carbofrax tile.
    (c) Floor in D-shaped fire clay.
2. The installation of very sensitive gas pressure controllers.
3. The installation of a 5,000 cu. ft. gas holder to act as a balance wheel in the gas system.

Mr. McIntire was then requested to submit at the earliest moment in writing his reports embodying the agreement reached for the betterment of conditions. These very important reports of Mr. McIntire appear as appendix No. 24 and the Board attached then, and still attaches great importance to them.

This brings to a close the history of the preliminary operation of the Stansfield carbonizer, and Section VI will relate the story of the final attempts to operate it.

SECTION VI

PERIOD OF FINAL OPERATION OF STANSFIELD CARBONIZER

Jan. 1922 to Jan. 1923

CONTENTS

General situation in January 1922, Reports of C. V. McIntire Reconstruction necessary, Further financial grants needed, Negotiations with three supporting Governments, Final action by Dominion Government, Reconstruction started and completed, New trial runs, Exhauster troubles hold up work, Consultations in West, Tentative policy adopted, Further operation, Conference of Jan. 8, 1923, Final decision to abandon, New control of Board.

No narrative of the work of the Lignite Utilization Board would be thorough or lucid without pausing at this point to call attention to its financial and technical situation, as existing in the beginning of 1922.

During November, 1921, it had been foreseen clearly that a crisis was approaching in the finances of the Board. It then became apparent that the amount of money on hand would not be sufficient to carry to a conclusion the carbonizer runs then underway, and in addition to meet the remaining payments on capital expenditure on plant construction. This financial stringency was due to the capital expenditure exceeding estimate (plant was constructed at period of maximum cost and minimum labour efficiency) and also to the fact that as the carbonizers did not function as predicted, the plant could not be put in operating condition.

The technical situation in regard to the carbonizers could be summed up in a word or two The Board believed that their mechanical operation had been proved (certain of the November and December runs were smooth mechanically). The Board believed that the principle had been proved (witness the comparatively good results attained once or twice when controls had been accurately established and obvious causes of trouble avoided), though the Board also believed that many of the constructional details were wrong and faulty. It was, therefore, felt that with improved methods in construction and control, success ought reasonably to be anticipated. This belief was confirmed generally by the painstaking reports already referred to, of C. V. McIntire of New York, with the one exception of Mr. McIntire's statement on capacity. If his prediction in this regard were true, then the carbonizers were condemned completely. The great claim for the Stansfield retorts was their apparent large capacity, because the capacity actually attained in Ottawa per square foot of heating surface had led to the belief that if the same unit capacity* were realized in Bienfait, the economy of the retort was beyond dispute. Consequently the Board believed that on this head Mr. McIntire was taking perhaps a pessimistic view. Speaking broadly of the other technical aspects of the plant the Board felt that everything was reasonably sound, and that the future hinged practically completely on the question of carbonizing.

*It is an interesting study as to why the unit capacity at Bienfait was so much lower than that attained at Ottawa. See appendix No. 17.

Under all these circumstances, it was decided that the original objective could be attained most quickly by the reconstruction of three of the carbonizers, and by the installation of certain gas handling machinery. To effect these changes, and to make provision also for working capital, (to purchase coal, binder, pay wages etc.) it was estimated that a sum of $250,000 would be required. It was next decided to bring the situation to the attention of the interested governments and ask for an appropriation in that amount — one-half of which would be requested for immediate payment, and one-half subsequently as the need might develop. It was expected also that the charges for working capital might be reduced when the time came, by the sale of briquettes made during the period of adjustment.

During November of 1921, however, the Dominion elections were imminent and nothing could be done until the political atmosphere had been cleared. On December 8th, 1921, the elections were held, but it was not until January of 1922 that the new Dominion Government was constituted and accessible for discussions of the lignite question.

Early in January 1922, the Board opened negotiations with Dr. Camsell, Deputy Minister of Mines, and submitted the whole matter to him informally with the request that he arrange an appointment at the earliest date with the Minister, the Hon. Charles Stewart. This was done and on January 19th., the Chairman and the Secretary met the Hon. Mr. Bostock (acting minister) and Dr. Charles Camsell when the whole matter was discussed thoroughly. Subsequently at the request of the Hon. Mr. Stewart a report was submitted outlining briefly the situation. This report, dated January 20th, 1922, appears as appendix No. 9.

The recommendations touched upon the required reconstruction, and asked for further financial assistance in the amount of $250,000 — one half to be paid immediately for reconstruction and testing, and the other half at a later date for working capital. Another interview was held a little later at which the Board was told that while the Dominion Government was not unsympathetic to further financial subvention of the Board's efforts, they did not feel justified in proceeding in the matter on their own initiative. The Federal Government suggested the Board should approach each of the two Provincial Governments interested with a view of obtaining their consent to the payment of their share (one quarter each) of the new amounts. The Board decided upon sending a representative to interview each of the two Western Governments and their Legislatures then in session. Owing to the fact that the Chairman had other committments which rendered it impossible for him to go, the Secretary was sent. On February 6th 1922, the Saskatchewan member, the Hon J. A. Sheppard, and the Secretary interviewed the Premier, (The Hon. Wm. Martin) the Provincial Treasurer, (Hon. Charles Dunning), and the other members of the Provincial Cabinet, and in the afternoon of February 6th 1922, the two Board representatives addressed the members of the Saskatchewan Legislature on the crisis then reached in the Board's affairs. This meeting took the nature of a thorough review of the work of the Board followed by questions and answers regarding the difficulties encountered and the criticisms that are inevitable in any public work. On the next

day, February 7th 1922 the Saskatchewan Government announced their decision to undertake their share in the further amounts, with the proviso that the Manitoba and the Dominion Governments did likewise. The Secretary then proceeded to Winnipeg, and in company with J. M. Leamy, the Manitoba member, interviewed the Hon. T. C. Norris, Premier, and the other members of the Manitoba Government. Over a week was spent in Winnipeg during which time the Secretary addressed a general meeting of the members of the Legislature, and also separately the various constitutent groups into which the Legislature was then broken up. On February 16th 1922, the Manitoba Government finally consented to undertake their share of this new grant, and the Secretary returned to Montreal. Negotiations were then opened immediately with the Dominion Government. The situation was recorded in a written report dated February 22, 1922, a copy of which appears in Appendix No. 10, but resulting negotiations proved to be very much longer than could have been reasonably expected. During all this time the actual financial affairs of the Board were in an extremely perilous condition — the mechanicians and other workmen on the Board's staff at Bienfait becoming more and more discouraged at the lack of employment.* The failure to announce any decision made many of them apprehensive, and not a few resigned. The same factors also affected the technical staff. It soon became a matter of acute anxiety as to how the Board could meet even its small payroll and salary list. Finally on March 3rd 1922, the Chairman went to Ottawa determined to obtain a decision but the results were quite inconclusive as regards money.

Never was the Board in a more critical state — its funds were exhausted — the men were discouraged with delays — and the staff anxious and disquieted.

The absolute immediate need of the Board was either cash or credit to enable its payrolls to be met and thus keep together the technical organization that had been gathered together slowly and which in the intervening months had learned to depend on one another. The Research Council of Canada, the godfather of the Lignite Utilization Board, suggested at this very opportune moment to the Governments on Friday, March 17th, that they would be willing to make a loan of $20,000 in order to assist the Board on the condition that the Board returned the money immediately its own funds were made available by the Government. The Hon. Mr. Robb kindly gave his O. K. to this suggestion, subject to the approval of the Hon. Mr. Stewart. At the same time the Secretary had arranged finally with the Department of Mines to give the Board an official letter stating that the grant of $125,000.00 was being included in the main estimates. With this letter he was able to negotiate a credit with the Bank of Montreal in the sum of $25,000.00 and thus the very serious financial crisis of the Board was tided over at least temporarily. By April 1st, 1922 all the outstanding liabilities of the Board had been liquidated with the exception of one or two that needed adjusting.

As soon as this temporary financial settlement had been reached, the Board placed its orders immediately for the material necessary to re-

*All the staff but the watchman and fireman had been laid off on Dec. 17th, 1921.

construct three of the carbonizers according to the suggestions contained in the reports and as suggested verbally by Mr. McIntire. Specifically the hollow Carbofrax tile, and the special fire clay shapes with the accompanying refractory cements, were the materials most urgently desired. As soon as these orders were filed with the manufacturers, the orders for the pressure regulators, meters, the gas holder, and extra piping were prepared and given to their respective vendors.

The months of May to September 1922 were given up to the reconstruction of the three carbonizers —one with the hollow carbofrax tile floor — one with the double thickness of flat carbofrax slabs — and one with special D-shaped fire clay slabs. Reconstruction of these carbonizers was completed on September 5th, and on September 6th, a slow fire was started in No. 1 carbonizer to heat it slowly in preparation for the first test run. For this run Edgar Stansfield had come down from Edmonton to be present in a consulting capacity. By September 8th, the carbonizer was ready for its first run, and runs were made on the 8th, 9th, and closing at about 5 P. M. on the 10th inst., due to heavy gas leakage in the expansion joints with resulting bad effects on the men. These runs are referred to in the reports as "D-1", while further trial runs were made during the latter part of the month under the index Nos. of "D-2", "D-3", "D-4" and "D-5", the details of all of these runs being covered in appendix No. 26.

As will be noted in previous appendices, very serious trouble had arisen with the exhauster used to pull the gas from the carbonizer chamber of the retorts. The original specifications laid down by the Lignite Utilization Board and accepted by the contractor (The American Chemical & Sugar Machinery Company) were for a positive exhauster to work at back pressure of 1-lb. which would correspond to about 27″ of water gauge. For some extraordinary reason the American Chemical & Sugar Machinery Company in reissuing the specifications to the manufacturers from whom they decided to purchase the exhauster required only 7″ of back pressure and in addition consented to accept a blower. This then was the total back pressure of which the blower was capable, and no thorough test had been possible until the time now under review, for in the runs of 1921 there was no gas holder and very much less regulation on the line. Under these circumstances the inability of the blower to fulfil the original specifications was not disclosed until it was tried to operate with a gas holder (designed for 6″ water gauge pressure) in series in the line. As it was useless to make further trial runs until this very important weakness had been corrected, the carbonizers were shut down until such time as the exhauster failure had been rectified. It is to be noted also that as the runs "D-1" to "D-5" inclusive were made on carbonizer No. 1 — the carbonizer that had been rebuilt in hollow carbofrax tile — the inopportune failure of the exhauster made it impossible to run comparative trials on carbonizers Nos. 3 & 5. The complete responsibility for this very serious error was accepted by the American Chemical & Sugar Machinery Company in a signed statement and at the same time they took responsibility for righting the matter at the earliest moment. Copy of this acceptance of responsibility appears as appendix No. 11. Within a comparatively short

time of receipt of this written acceptance, and certainly before shipment of the apparatus which they had promised to furnish could be effected the American Chemical & Sugar Machinery Company went into temporary liquidation. The Board immediately placed its claim in the hands of the Company's Receiver but to date of writing this claim has not received any adjustment, owing to the apparent fact that the assets of the Company will not even pay the expenses of liquidating. As the delay would have proved extremely serious, the Board placed orders on their own responsibility and on their own guarantees for some of the material that should have been shipped by the American Chemical & Sugar Machinery Company, in order to have the plant operating at the earliest moment.

These various negotiations with the American Chemical & Sugar Machinery Company were made by the Secretary during October, 1922, and while passing through New York, the Board's Consulting Engineer, Mr. C. V. McIntire, mentioned to him that Mr. O. P. Hood, Chief Mechanical Engineer of the United States Bureau of Mines, had just returned from an investigatory trip to Germany where he had observed the latest practice in regard to the treatment of German brown coals. Mr. McIntire suggested that it would be well worth while to send a representative to Washington to interview Mr. Hood in order to hear the latest developments along these lines. To this suggestion the Board agreed, and on Nov. 8, 1922, Mr. McIntire and the Secretary went to Washington to interview Mr. Hood. As the results of this conference were of far-reaching consequence to the Board, the journal of the visit is included in this report as appendix No. 41. It is sufficient to note here that the Secretary returned to Montreal very much impressed with the economy and simplicity of the Hood-Odell oven, which had been developed within the previous few weeks at Grand Forks, N. D., through the cooperation of the American Bureau of Mines and the University of North Dakota — Dean Babcock.

In order to enable the Chairman to get a more intimate knowledge of the progress of affairs at Bienfait he instructed the Secretary to go to the West on November 14th, see conditions at the plant, see Stansfield, interview the two Premiers, and if possible effect a statement of immediate policy for the future. On November 14th, therefore, the Secretary left for the West and as a result of his visit, discussions, interviews, etc., the Board recorded its decision and position as at December 8th in the following language.*

> "By the completion of the 5th run practically perfect operation of the carbonizer had been obtained. Lignite was carbonized regularly and every interruption encountered could be accounted for clearly without any doubt existing as to its cause. Except for exhauster troubles, no outstanding difficulty was met with to prevent the Board from carbonizing lignite continuously in this apparatus, with, however, the possible exception of cracks, which have developed in the floor material. It will be

*Extract from Progress Report dated Dec. 8th, 1922.

recalled that in the trial runs of 1921 this was one of the fundamental difficulties encountered, but the manufacturers were insistent that a large improvement had been made in the quality of their product. It is too soon yet to report that the new carbofrax material is a failure. On the other hand, we are disapointed and somewhat anxious that cracks should be developing so soon. It is probable that future cracking may be prevented when operating the carbonizers continuously in the near future, and it is quite possible that the cracks may be due to the very hard treatment that necessarily was present when testing No. 1 retort. In other words, the constant heating and cooling might easily be more than any fire brick construction could withstand."

"The difficulties encountered in operation were in the main chargeable to the exhauster. When any attempt was made to bring the combustion chamber up to high working temperature the amount of gas produced became too great for the exhauster to pull away. This condition was very baffling until it was discovered that the apparatus furnished to the Board was not in conformity with the specifications for same originally approved by the Lignite Board. This discrepancy could only be made evident upon operation — and when so disclosed, steps were taken to hold the vendors responsible. A written admission of this responsibility together with a written agreement for replacement of apparatus was thereupon obtained. Before the vendors could complete this order, and effect shipment they went into temporary liquidation, and the matter is being handled now by the Board's lawyers. In the meantime, in order not to hold up the work, the Board has placed orders for changes and revisions, assuming responsibility of payment themselves. The new rotor for exhauster and small steam turbine for driving the machine are now on the way to Bienfait, and will be installed within a short time."

"To sum up, the Board states that:—

(a) It does not regard the work done to date on No. 1 retort as having proved complete success. On the other hand it is a long way from failure. A retort may be looked at from three points of view: Does it operate? Is the design as nearly correct as present knowledge enables it to be? and thirdly — is the capacity commercial? It is self evident that failure from the first mentioned point of view would spell complete disaster for any retort. From this point of view it can be stated that our No. 1 retort is a success. In other words, it operated for a long period with no serious interruptions to flow of coal, etc. The only qualification of this general statement lies in the possible break-down of the carbrofrax floor material

to which reference has been made already. This achievement is a distinct advance gained over last year's work. From the point of view of design, we feel that the amount of research work done by Mr. Stansfield and others, since the construction of this retort, would enable us to prepare today a superior design, both as regards economy of heat and transference of same to lignite coal in passages. Under the remaining head of capacity, the Board is disappointed with the showing made to date, which is briefly that the discharge is only about 50 to 60% of what it was calculated to be. In addition auxiliary fuel was necessary owing to the large amount of heat that is diverted to the rotary dryers. The figures on capacity are subject to some improvement, and perhaps to a very marked improvement, when our exhauster troubles are solved, and when three or more carbonizers are in operation in parallel. Condensing the Board's opinion on the question of carbonizing, we would say that we have not yet achieved success, but we are a long way from failure. In other words, enough success has been achieved to warrant us in recommending the prosecution of the programme hereinafter referred to."

"(b) In the departments of raw lignite handling, drying, briquette cooling, briquette storage, power plant, water supply, housing and sewage disposal, the Board would report that everything is in reasonable condition though as yet it has been impossible to undertake full duty trials."

"(c) In the department of briquetting the Board is not at all satisfied with the layout which it possesses at Bienfait, but is of the opinion that successful briquetting can be accomplished there, and that major revisions should only be undertaken when the fuller knowledge that hard continuous operation will produce, becomes available."

It is to be borne in mind in connection with the foregoing statement that only one carbonizer had been tested, and that test had been held under very discouraging circumstances as regards gas pressure control due to the failure of the exhauster. In order that the Board could reach what they regarded as a sound opinion as to the strict actualities of the situation, they had had to make an endeavour to read between the lines of the evidence available, to make certain suppositions, — to weigh as carefully as might be the balance between the contrasting inferences of observed phenoma, — to make what allowance they could, not only for known troubles, but for unsuspected difficulties.

While in the West the Secretary confirmed also arrangements for a round table conference with the Governments concerned. The situation was that long delays had taken place in the work from the time originally specified. Success seemed to be somewhat distant

and there was in the minds of the three supporting Governments a not unnatural feeling that they were not sufficiently in touch with the venture in order to commend it vigorously to their respective legislative bodies. Under these circumstances the Hon. Mr. Dunning suggested a round table conference of all interested parties to be held toward the end of December, 1922, and it was agreed to hold the conference either in Winnipeg or in Ottawa at the earliest date.

While at the plant the Secretary met the two Western Members of the Board and discussed thoroughly with them and Roche and Strong a tentative policy for a period of 4 to 6 months. As the attitude of the Board at that time in regard to policy cannot be set out more clearly than by Thomson's memos and minutes, it is worth while to refer the reader at this point to his report of pros and cons of the various alternatives that then presented themselves. This analysis and digest appears as appendix No. 42. It is to be borne in mind that the policy recommended was based on the experience available at the time, as modified naturally enough by personal estimates of the degree of amelioration that a proper exhauster and the operation of three carbonizers in parallel would have made in the actual performance of one carbonizer. From the close of the conference in Bienfait until the end of December nothing transpired to change the opinion of the Board, and early in January, a draft report was prepared in Montreal along these lines with the idea of submitting the same to the round table conference due to be held in Winnipeg on January 8th, 1923.

During the month of December 1922, a new rotor for the exhauster was delivered, and on Jan. 2, 1923 the steam turbine for operating same; and by Jan. 8th these new units were installed. In conformity with the policy agreed upon at the November conference in Bienfait, the Winnipeg conference was held on Jan. 8th, 1923, when it was decided to close down the plant for a time. It is seen, therefore, that no actual operation with the new exhauster rotor was ever held. Carbonizer runs using bleeders had been carried forward with vigor, and it was arranged that either Roche or Strong would meet the Chairman and Secretary in Winnipeg upon the occasion of the round table conference with the idea of bringing a verbal report with them as to the degree of success that had been attained on these new trials. These then were the arrangements conceived in conformity with a policy upon which no little amount of thought had been given. It was a policy that was only embarked upon with a determination to drive the plant to its capacity in order to elicit those results of great importance that such a trial alone could give, — and to disclose further weaknesses and faults that became apparent only under periods of severe mechanical strain.

On arriving in Winnipeg, the Chairman and Secretary met Roche, and received verbally a most discouraging report of new weaknesses and breakages that were formerly unsuspected, — of operating difficulties not before encountered, — of old difficulties largely increased, — of grave risks in operating the gas system due to leakages at the retorts, and of gallant effort on the part of the staff in battling against very severe odds, dogged by a succession of reverses. The burden of the report was that the carbonizers were not and could not be made

commercial. While it was possible that the carbonizers might even yet be made to operate, the delicacy of their controls, their sensitivity to small variations of external conditions, their want of elasticity in accommodating themselves to changes in atmosphere, feeding conditions, discharge conditions, etc., all combined to demonstrate to the minds of the resident staff at Bienfait, that they did not and could never discharge their expected and predicted functions. But as the Board's objective from the beginning had been to commercialize a process, to demonstrate that this method of treating a low grade lignite to produce a high grade domestic fuel could be made commercial, then insofar the word "failure" was writ large and clear upon the Board's carbonizing endeavours.

The problem now before the Chairman was to decide almost instantly as to where the balance of the probability in the future lay. Had the resident staff at Bienfait taken a perhaps too gloomy view owing to their gallant struggle alone against heavy odds? Should the tenor of the Board's report to the round table conference be, — 'Things have gone wrong temporarily but our proposition still is sound,' or should the report be, — 'These carbonizers are a failure from a commercial point of view.' If the latter were the proper course then the work of years would have to be cast aside and the future faced clearly, and full responsibility accepted. Then would the Board be accused of capriciousness in deciding and announcing one policy in December, and an entirely opposite policy in January. These and kindred problems had to be met squarely, decided soberly, and decision announced with no timidity. But new experience and fresh evidence must, in the minds of reasonable people, always constitute an imperative reason why a previous decision should be reviewed and if necessary altered. The record of the runs of December 27th to January 5th was unquestionably far more discouraging and the troubles encountered far more grave than anything yet disclosed. Under these circumstances the Chairman announced to the meeting that the Board would abandon immediately any further development of their own carbonizers. For the minutes of the salient feature of this meeting the reader is referred to appendix No. 12.

The Board at the close of the meeting found itself in a peculiar position. After all their hopes in their own carbonizers, and the confident expectations of success in their performance, they had now to state that they were a failure from a commercial point of view, nor could they guarantee any other carbonizer that would operate successfully. The only light they would cast on a rather obscure and sombre situation was that afforded by the reported performance of the Hood-Odell oven during the preceding summer to which reference has already been made in this chapter in connection with the Secretary's visit to Washington. This report was confirmed by some interesting tests made during the preceding few weeks by R. A. Strong on a model made in Bienfait of the Hood-Odell oven. The Board took the attitude that it was, as far as they could judge, the only apparent avenue of escape from the present dilemma, and recommended that a large sample shipment be sent from Bienfait to the oven at Grand Forks provided arrangements could be made through the courtesy of the American

Bureau and Dean Babcock. The Dominion Government's technical representatives also recommended the same course of action. After considerable discussion the three participating Governments accepted these unanimous recommendations and the Board was instructed to undertake the arrangements.

It now remains to record a very striking change, which took place at this meeting, in the relationship between the Lignite Utilization Board and the three supporting Governments. To this date the Board had pursued its work in an atmosphere singularly free from outside influence. With one or two slight exceptions no attempt had been made whatever, to influence, to change, to alter, to lead, or to suggest any decision, policy or action of the L. U. B., and the Board would be distinctly remiss if it failed to record at this point its very heartfelt appreciation of the freedom which it had enjoyed from its foundation to January 1923. This freedom of course was distinctly envisaged and bargained for by the Chairman on accepting office, and in preparing this report he wishes to avail himself of this chance of recording his personal appreciation of the fairness and the loyalty with which the three Governments up to January, 1923, observed the understanding. Now, however, a subtle change came over the situation. Not unnaturally the Governments were very far from satisfied with the results to date. Their dissatisfaction was justifiable from certain points of view, or at any rate understandable. Whereas formerly the decisions and policies of the Board had been under the Board's own control, from now onward the real control passes from the Board to a committee whose membership while not defined was very real, and the management of the enterprise reverts to "conferences" held periodically of all the interested Governments with the Board.

The alteration in the status of the Board is recorded here as a plain record of a change in the conduct of the enterprise. From January 1923, to the date of this report, the Board therefor has been sometimes in a position of being asked specifically to execute work that in certain cases did not commend itself to its judgment as being either essential to the conduct of the work, or, though perhaps desirable, as likely to yield results commensurate with the cost.

Immediately after the Winnipeg meeting, and in accordance with the decisions reached, the Board closed down the plant to the utmost degree, in fact to a point where there were but two or three men on the payroll other than the salaried officers, and concentrated all their attention on preparations for the test on the Hood-Odell oven at Grand Forks.

This section closes the history of the final period of the Stansfield carbonizer, and Section VII will discuss the Hood-Odell development.

SECTION VII

PERIOD OF HOOD-ODELL DEVELOPMENT

Jan. 1923 to Jan. 1924

CONTENTS

To obtain permission for the holding of the test on the Hood-Odell oven at Grand Forks, negotiations were immediately opened with the American Bureau of Mines and with the University of North Dakota, Dean Babcock. One hundred tons of screened lignite were prepared for shipment to Grand Forks, but owing to the lack of facilities for screening this coal rapidly the operation took considerable time. The screened sizes used were those recommended by Mr. W. W. Odell, of the American Bureau of Mines, who with Mr. Hood, Chief Mechanical Engineer, and Dean Babcock, had developed the oven. The tests were held at Grand Forks between February 7th and February 16th, 1923, in the presence of the following representatives of the interested parties:—

Representing the Lignite Utilization Board	J. M. Leamy, I. F. Roche, R. A. Strong.
Representing the Dominion Government:	Ross Gilmore.
Representing the American Bureau:	W. W. Odell.

During the test the most extraordinary weather prevailed — blizzards and storms, — and low temperatures were practically continuous. This factor would not have to be mentioned were it not that the oven was outside of any shelter, exposed to the rigors of winter conditions on the prairie.

The original intention when building this experimental oven had been to confine the tests to summer operation only. This permitted the main walls of the oven to be quite thin and made housing protection unnecessary. Under these circumstances it is apparent that the temperatures and operating conditions in the interior of the retort would be affected to no small degree by the exterior conditions of wind and temperature. In fact it proved to be impossible to run the whole 100 tons through the retort as, owing to adverse weather conditions, the requisite temperatures inside the oven could not be maintained. Sufficient work was done, however, to obtain general data sufficient for the Board to present a Progress Report in the beginning of March.

In conformity then with the decision reached on January 8th, another meeting was called, to be held in Winnipeg on March 3rd, in order that the results of the tests in Grand Forks in February might be communicated to the three supporting Governments. At this meeting the following were the official representatives:

Representing the Dominion Government:

Dr. Chas. Camsell,
B. F. Haanel.

Representing the Government of Saskatchewan:

Hon. Mr. Gardiner,
T. M. Molloy.

Representing the Government of Manitoba:

Hon. Mr. Bracken,
Hon. Mr. Craig,
Hon. Mr. Black,
Hon. Mr. Clubb,
Hon. Mr. Cameron,
Mr. D. L. McLean,
Provincial Deputy Minister of Public Works.

Representing the Lignite Utilization Board:

J. M. Leamy,
Lesslie R. Thomson,
I. F. Roche,
R. A. Strong.

The general tenor of the report of the Lignite Utilization Board can be summed up as follows:

1. The Hood-Odell retort as at present developed, is not absolutely out of the experimental state, in other words it is not developed to the point that the Board had hoped and apparently had been led to believe.

2. The amount of success, however, certainly warrants the erection at Bienfait of one or two of these retorts and that they should be tried out over a period of at least six months.

3. In view of the shortness of time between the close of the experiments at Grand Forks, and the present meeting, that actual details of these retorts be left over for the decision of the Board's engineers.

4. That in addition to the amount of money authorized for the construction and operation of the Hood-Odell retorts, the Board also be authorized to proceed with the changes in the present briquetting layout. In this connection the Board would be glad to have any financial restrictions placed on the expenditure of this money that the Governments may care to lay down.

Dr. Camsell on behalf of the other technical representatives of the Dominion Government, and Mr. Ross Gilmore presented a report which could be summed up as follows:

(i) The Department of Mines, Ottawa, does not believe that the Hood-Odell retort is out of the experimental stage of development.

(ii) Enough success was achieved, however, to warrant the construction of one or two of these ovens at Bienfait.

The whole situation was then thoroughly discussed and the difficulties in the way of the two Western Governments in regard to further financing were pointed out. On behalf of the Board the Secretary submitted a rough memorandum of the cost of building one of these retorts and operating it for a period of six months — namely $40,000. He also stated that the Board had on hand approximately $24,000 (This turned out subsequently to be in the neighbourhood of $23,400). After a thorough discussion of the whole question the following action was agreed upon unanimously:

1. That the Lignite Utilization Board be authorized to utilize the $24,000 at present standing to their credit, to construct and operate a Hood-Odell Retort as a unit of the Government's plant at Bienfait.
2. Following this experimental work the Lignite Utilization Board will report to a Conference of the Governments interested.
3. In order to make available if required the $125,000 voted by the Dominion Government last year, the Governments interested agree to sign a new agreement, so that this amount may be used for further experimental work, provided however, that the Lignite Board reports favorably on the Hood-Odell Carbonizer, and the unanimous consent by the three Governments interested is secured for any further expenditure.

On reference to the foregoing three decisions it will be noted that the Board was instructed to build one Hood-Odell oven, and to operate the same until the capital charges and operating charges had used up the quoted sum of $24,000.

To implement this decision the Board immediately get in touch with Mr. O. P. Hood, Chief Mechanical Engineer of the Bureau with the idea of concluding arrangements for them to act as the Board's Consulting Engineers in this specific matter. This very courteous offer had been made by the Bureau some little time previously, and the very sincere thanks and deep appreciation of the Board are here recorded. After the necessary arrangements were completed the Bureau was requested to prepare immediately the necessary construction drawings for a new oven so designed as to incorporate all those improvements, suggested as a result of experience gained by operation, both of the original runs at Grand Forks during the summer of 1922 and of the special winter run of February 1923. In order that this might be achieved Mr. Odell proceeded to Bienfait so that there might be a complete pooling of the ideas of himself, Strong and Roche. On April 20th the Board received from the Bureau the detail and construction drawings, and the necessary orders for new material were placed immediately. Arrangements had also to be made with the Saskatchewan Government for the loan of a roll crusher (through the courtesy of R. N. Blackburn) used to prepare the raw lignite to conform to the desirable screen analysis. The insurance companies had also to be consulted, and a decision had to be made as to the best position on which to erect the oven in order to utilize to the greatest degree possible the existing coal handling and conveying machinery. Its final location is shown on general plot plan, — Fig. No. 20. Construction work on

the oven was started on May 2nd, and completed on June 21st. During the time of construction, arrangements were made for the supply of the requisite amount of raw lignite, and negotiations carried out for the lowering of the insurance rates due to the reduction in hazard occasioned by the fact that the bigger carbonizers and dryers were shut down. During this time also paper studies were made in connection with the improving of the briquetting building. Operations on the oven were started at 9 a. m. on June 25th, as Mr. Odell had arrived at Bienfait on June 23rd with the object of being present for the first runs, of which the character will be recorded a little later in this report. It is sufficient to state here that the first run was from June 25th until July 3rd, when it was suspected that some of the cast iron baffles had been burnt out. The oven was thereupon stopped, emptied and cooled, new baffles were inserted and some minor changes made. On July 13th, the oven was again started and was operated continuously until August 21st.

Between these two dates, however, important decisions affecting the future of the Board were made and it will be necessary to introduce these now into the narrative and to defer for a short time the general description of the work on the Hood-Odell oven.

It will be recalled that the Lignite Utilization Board was authorized on March 3rd, 1922, to build one of these Hood-Odell ovens and operate the same until such time as the sum of $24,000 would have been expended. It became apparent early in July, 1923, that this point would have been reached by the end of that month. The Deputy Minister of Mines, Dr. Camsell, who had some time previously been requested by the Province of Manitoba to act as their technical representative in connection with this matter, was therefore notified of this fact; and the suggestion was made to him that the agreed upon meeting be held about the end of July in order that the supporting Governments might determine their future policy. A meeting was therefore called to be held in Winnipeg on July 30th, 1923. Among those present were the following:

The Hon. John Bracken	— Premier, Province of Manitoba.
The Hon. W. R. Clubb	— Manitoba.
D. L. McLean	— Deputy Minister of Pub. Wks. Man.
The Hon. Jas. G. Gardiner	— Regina, Sask.
The Hon. Mr. Cross	— Regina, Sask.
Dr. Chas. Camsell	— Ottawa, Ont.
Ross Gilmore	— Ottawa, Ont.
J. M. Leamy	— Winnipeg, Man.
Lesslie R. Thomson	— Montreal.
I. F. Roche	— Bienfait, Sask.

To this meeting the Lignite Utilization Board presented an important report dated July 27th, copy of which appears as appendix No. 13.

The Winnipeg Meeting divided itself roughly into two parts, a morning session held in the office of the Premier, and an afternoon session held in the Hon. Mr. Clubb's office. At the morning session, a general discussion took place on the recommendations of the Board,

on the report on the experiment by Mr. Gilmore, the Dominion Government's representative at the test, and other related matters. It will be noted that the Board's recommendation at this meeting was for a distinct forward movement in order to produce results, to save the necessary overhead, and in other ways effect the truest economy in the development of the general project.

The afternoon session was held in the office of the Hon. Mr. Clubb, Minister of Public Works, with Mr. Clubb in the chair. Mr. Clubb stated that there had been a meeting of the Manitoba Cabinet since the morning session, and that Manitoba in view of the wording of their vote could not consent to any expenditure of her share of the money for further experimental work — it having been voted ostensibly for commercializing the project. It was therefore beyond their power, without further legislation, and under the circumstances, they had decided to withdraw from the project entirely. On behalf of the Board the Secretary ventured to submit two questions:—

(a) In the event of the remaining two partners meeting the present experimental expenses, would Manitoba be willing to contribute her share ($31,250) for working capital at a later date. To this question Mr. Clubb replied that he could not commit himself, but it was possible.

(b) As all parties to the undertaking were now represented did they desire to reach any decision respecting the plant. In other words, did they wish to close it down, disband the staff, or did they want the work carried on for a time.

This extraordinary and entirely unexpected decision of Manitoba taken at a time when both the Board and Dominion Government had submitted the most favourable technical reports that had been tabled since the original carbonizer difficulties had occurred, made it necessary for the various representatives to refer the whole question of policy back to their respective Governments. This becomes a fitting example of the inability of mixed committees to handle expeditiously a technical problem of this kind. It is only fair, however, to state in this connection that the action of Manitoba was quite understandable, and their situation must be visualized for a moment. The Provincial Government had found themselves since their election in very straitened financial circumstances. The strictest economy obviously was necessary in every particular.

To the remaining two Governments, however, the decision seemed so unfortunate that considerable hope was expressed that it might be possible for Manitoba to reverse her decision upon further consideration. To that end negotiations were undertaken between Ottawa, Regina and Winnipeg, but it was not until the middle of September, 1922, that Manitoba finally confirmed its decision to have no further participation in the finances of the Lignite Utilization Board. In these negotiations looking to a continuance of support of Manitoba the Lignite Utilization Board had no part whatever.

The position of the Board must now be reviewed for a moment in order to make the subsequent decisions clearer. As already men-

tioned the Board prepared and submitted an important report to the meeting held in Winnipeg on July 30th. See appendix No. 13. This report was not acted upon or accepted at the time. Manitoba threw a virtual bombshell into the meeting by announcing its decision to withdraw. Upon agreement with Dr. Camsell and the Hon. Mr. Gardiner, the Board continued the operation of the Hood-Odell oven and the conduct of minimum services at Bienfait. From July 30th until September 14th, the Governments were negotiating as to the possible continuance of Manitoba's support, but on the latter date the Hon. Chas. Stewart announced to the Board the final decision of Manitoba to withdraw and it then became necessary for the two remaining partners to determine their policy. On reference to the Board's report of July 27th, 1923, it will be noted that the recommendations made were based on the assumption that the financial resources of the Board would be in the heighbourhood of $125,000. The withdrawal of Manitoba produced an entirely different situation because with only two partners remaining, it became apparent that as at October 1st, 1923 the Board's liquid assets would only be about $75,000. This reduction would be caused by the repayment to Manitoba of her unexpended share ($31,250) and the absorption of operating charges and current liabilities if the Board were to be closed down as at the latter date. The question of further financial subvention by the two remaining Governments was considered to be quite hopeless unless distinct and favourable advances could be recorded in the fields of carbonizing and briquetting. To that end the Hon. Chas. Stewart requested the Board to submit a written recommendation for immediate policy, governed, of course, by the financial limitations just mentioned. In other words, the Board was requested on September 14th, to submit immediately a written recommendation for the quickest way to get the greatest results with the least expenditure. This request was made verbally by the Hon. Mr. Stewart to the Chairman and the Secretary when the latter were in Ottawa at his request. In the limited amount of time available (about an hour and a half or two hours) the Board considered the matter and submitted that afternoon such a memorandum to the Hon. Mr. Stewart, and a copy of this dated September 14th appears as appendix No. 14 of this report. This written recommendation was given to the two supporting Governments to consider and to take such action upon as they might see fit. Again it will be noted that the decisions on policy were not with the Board. When presenting this report to the Government's representatives, the Secretary again urged them to feel quite free to suggest or make any changes in the method of carrying out the whole project; in the composition of the Board; in the disbanding of the Board if desired; to transfer the work to a Government Department; or to take any such other action as might lead to a quick realization of the common objective so ardently desired, namely the production of briquettes in commercial quantities.

The interested reader might ask at this point why did the Board submit to any interference of this kind when the whole matter could have been settled by handing in their resignation. It will be recalled that no member of the Board was under salary or emolument whatever. The work was entirely honorary. It would therefore have been very easy to have adopted an air of injured dignity and resign; and the

Board wishes at this point to record the fact that at the January meeting by the Chairman, and at the March and July meetings by the Secretary, both official and informal assurances were given that if they (the Governments) desired the resignations of any or all of the Board, the Board would only be too happy to submit the same. The Board assured the Governments at each of these meetings and also the Hon. Mr. Stewart and Dr. Camsell on September 14th that the work was of far greater importance than the feelings or personalities of those connected with it. The best evidence of the Board's willingness and anxiety to see this national work pushed to successful conclusion can be found in their oft repeated assertion that if by resigning they could advance the work, they would be glad to do so, or if by remaining at their posts they could advance the work, this likewise they would be glad to do. In other words, personalities or personal desires, connections, or feelings, were of infinitely less importance than the competent prosecution of the work to a successful conclusion. If, therefore, the Board had been mistaken in putting up with this situation it has been due to an honest desire to discharge its plain and simple duty.

As above mentioned the memorandum of September 14th, 1923, was left with the two Governments as represented by the Hon. Mr. Stewart and Hon. Mr. Jas. Gardiner. Upon receipt of this memo. the two supporting Governments sent out investigators of their own to satisfy themselves as to the wisdom or otherwise of the recommendations. On September 25th, they had received reports of their own representatives and requested the attendance of the Lignite Utilization Board. The Secretary was sent to Ottawa to interview them and on that afternoon received their decision as follows:—

(a) The Lignite Board will continue the operation of the present Hood-Odell oven until the end of December, 1923.

(b) The Lignite Board will ship at the earliest moment 150 tons of lignite char from the Hood-Odell oven, of which 125 tons will be of low volatile content and 25 tons of high volatile content. The Lignite Board will also make arrangements with the authorities at Hebron to run this char through their briquetting plant with observers present representing the Board and the Governments interested. The Board will also have the resulting briquettes shipped to such points as directed by the Governments.

(c) The Lignite Board will present an interim report on this briquetting run at the earliest moment thereafter.

(d) The Lignite Board will prepare their final report for submission about the end of December, which report will contain, of course, the substance of the interim briquetting report.

It will be noted that this agrees with half of the recommendation made by the Board itself on September 14th, but defers action on the remaining half, substituting therefor a trial briquetting run at the Hebron plant. The representatives of the Government had returned with the assurance that the authorities at Hebron would be able to make an immediate test, but unfortunately this information proved to

be erroneous, and it was not until December 8th that the test was commenced, with the last run on December 20th. As a preliminary measure the Board shipped a small amount of lignite char of different kinds to Grand Forks, North Dakota, to be briquetted at the experimental plant at the University, which run had been arranged through the courtesy of Dean Babcock. This run was undertaken to determine action on briquettes of such variables as, percentage of volatile matter in char; use of lignitic pitch, etc.

The foregoing instructions on policy divide themselves into two parts — those having to do with the Hood-Odell oven, and those having to do with briquetting. The latter parts are dealt with in Section VIII, and it only remains now to sketch the work on the Hood-Odell oven until the close of December 1923.

During the operation of the oven after its first and second shut downs, it became apparent that the life of the cast iron baffles was not indefinite, and thought was given to the substitution of baffles of some of the modern high temperature metals. It was found that if the whole baffle were made as originally designed, in one or two of the high grade metals, the cost would be prohibitive. Two solutions were suggested, one with tips only in the high temperature metal, and the other with a much lighter baffle. Owing to one of the manufacturers' failure to live up to promises it was only possible to test out two kinds of baffles, and then for a period of one month only, whereas the life of a cast iron baffle appears to be at least two months. The report on these matters will be found in appendix No. 27, by R. A. Strong, which presents a complete record of the Hood-Odell oven operation.

In accordance with the Government's instructions the Hood-Odell oven was shut down on Dec. 31st, 1923, and immediately afterwards, the work of closing down the plant was undertaken. At date of writing, the plant is completely shut down, and all workmen are discharged with the exception of watchmen and fireman. The latter are necessary to maintain fire protection services.

SECTION VIII

BRIQUETTING

CONTENTS

Previous to the creation of the Lignite Utilization Board in 1918, the Department of Mines, Ottawa, had done valuable work on the briquetting of lignite chars. This work had been undertaken by Messrs. Stansfield and Gilmore, using a small hand plunger press. The briquettes produced were fabricated, therefore, one at a time, and thus possessed only an experimental or scientific value. By 1919 enough work had been done by the Department to bring forcibly to their attention the capacity as binder agents, of hard wood tar pitches, coal tar pitches, and sulphite liquor pitches.

As a result of the 3rd meeting of the Board, held Feb. 10,1919—See Section 11 — the Ottawa staff had been launched upon an investigation of both carbonizing and briquetting. It therefore became necessary to decide at once on the type of press to use in the investigations.

Figure 7 referred to in the report appearing as appendix No. 16 of Stansfield and French gives a digest of the briquetting plants in North America in operation during the early part of 1919, and Plate No. 1, a photo of their respective products. It is interesting to note that three types of presses were used, roll presses, Rutledge presses, and Komarek presses. See Plates 2 and 3. The last named is a modified roll press, while the Rutledge is an American plunger press turning out briquettes of from 10 to 16 ounces in weight. It will be observed that of 13 briquette plants listed (one of which had two installations), eight (8) use the simple roll press producing small briquettes, and two use the Komarek roll press producing small briquettes, and four use the Rutledge plunger press, producing large briquettes. Thus 10 of the total 13 plants were producing a small briquette. Of the others the output of one of the Rutledge presses was destined practically entirely for export to South America. It is not within the purview of this section to discuss the relative merits of roll or plunger presses, but suffice it to say that British, French and German practice has been in the main to produce a large briquette of from 12 ounces to two or more pounds in weight, with however a good proportion of the output of the British plants destined for export, because the large briquettes are usually superior in their shipping qualities.

As the objective of the Board was to prepare a fuel for Western Canadian consumption and not for export, it was decided that a small briquette either pillow shaped or ovoid of about 2 ounces would be more suitable for the domestic furnaces in the West, which, without exception, were designed to burn American Anthracite. Having reached a decision upon this point, it was then concluded that a roll

press would be cheaper in first cost, simpler in handling, and more economical in maintenance. Therefore all research work was limited to briquetting with a roll press, the acquisition of which has already been touched upon. Appendix No. 37 lists the specific briquetting objectives laid down for prosecution at Ottawa. For convenience these objectives are here repeated.

i) *Investigations into the relative suitability for briquetting of lignites carbonized at different temperatures.*

ii) *Investigations to determine best fineness of material to be briquetted.*

iii) *Investigations into available binders as to amount, and proportions for mixing.*

iv) *Investigations as to type of mixers, in other words would paddle mixers or grinders prove the more effective.*

v) *Speed of operation of rolls.*

vi) *Secondary heat treatment of briquettes to render them smokeless.*

vii) *Briquette testing methods, etc.*

Section III has mentioned the research laboratory set up in Ottawa, of which the briquetting equipment was as follows:

(a) One roll crusher for pulverizing coal.
(b) One small ball mill.
(c) One small steam jacketed mixer.*
(d) One large horizontal paddle mixer.
(e) One drying plate.
(f) One rotary dryer.
(h) Such auxiliary equipment as scales, blower, meters, etc., etc.
(g) One Mashek type Y-1 three pocket roll press as illustrated on Page 70 of the No. 4 Catalogue of the Mashek Engineering Co., New York. This press was selected owing to the fact that though quite small it was a commercial unit. The results obtained from its use would be applicable to commercial conditions with large apparatus.

Fig. 3 illustrates the layout of all this equipment.

It remains now to discuss the results of the investigations above listed. It will be simpler to discuss them under the headings (i) to (vii) as above mentioned.

(i) *Effect on Briquetting Results of Varying Carbonizing Temperatures.*

The investigations into the relative suitability of lignite carbonized at different temperatures was not prosecuted completely owing to other factors in the situation. It is to be noted that, as the final objective of the Board was to commercialize a fuel process, it was essential that the greatest possible number of B. T. U's. be left in the lignite residue after carbonization. As a result of the researches on Carbonization (See "Carbonization of Canadian Lignite" by Stansfield — Journal Industrial and Engr. Chemistry. Jan. 1921) it developed that carbonization at approximately 600° C., yielded a residue having

*This mixer is small and used commercially as a bread kneader being manufactured for bakers' purposes. It was not suitable for mixing large quantities of lignite, but with small batches, made a most satisfactory machine.

the highest B. T. U. content. Such a residue was therefore laid down as the desired objective, and no peculiar difficulty was anticipated or discovered in briquetting char carbonized at that temperature as distinct from char carbonized at other temperatures. In fact standard briquettes had been made with residues carbonized at widely different temperature. (In this connection see results of work at Hebron and Grand Forks in December 1923, appendices 30 and 31.)

The following are the typical chemical analyses of the carbonized residues as discharged at varying intervals from the semi-commercial carbonizer in Ottawa. (for description of this, see Section III p. 33, and appendix No. 18.)

	2 min.	2-½ min.	3 min.	4 min.
Moisture	0.0	0.0	0.0	0.0
Ash	19.6	19.6	21.2	22.7
Vol. Matter	18.6	17.8	11.1	6.5
Fixed Carbon	61.8	62.6	67.7	70.8
B. T. U.	11,140	11080	11180	11150

(ii) *Fineness.*

The investigations to determine the best conditions for briquetting as judged by screen analyses, were not pushed to a final conclusion owing to the fact that fineness is not an independent variable, but is intimately connected with binder discussed under — iii.

It has already been noted that a roll crusher for pulverizing lignite had been installed in the Ottawa laboratory. In addition there was a small coffee mill, which was found extremely useful, because as a matter of repeated observation it was discovered that the coffee mill gave a sized product that appeared to make an excellent briquette. Consequently this product was adopted more or less as a standard, and was often referred to as "coffee mill size".

The following is a screen analysis of some lignite analysized after passing through the coffee mill, and carbonized at 600° C in the cruciform retort.

Screen Size	%	Cumulative %
— 10 + 20	60.1	60.1
— 20 + 40	21.8	81.9
— 40 + 60	8.0	89.9
— 60 + 80	3.3	93.2
— 80 + 100	2.1	95.8
— 100 + loss	4.5	99.8
	0.2	100.0

It will be noted that there are no lumps over an eighth of an inch in size. Figure 8-a represents an average screen analysis of fourteen samples of carbonized residue. The curve shows that on the whole the material is of fairly uniform consistency. The figures Nos. 9 and 10 give a tabulated digest of several screen analyses of a number of briquetted coals as compared to the carbonized residue used by the L. U. B., and of the effect of carbonization on the residue. The phrase "rolls 1" and "rolls 2" refers to the roll crusher mentioned previously.

(iii) *Binder Investigations.*

Bulletin No. 24 of the Bureau of Mines, Washington, and the previous work of E. Stansfield and R. E. Gilmore of the Department of Mines, Ottawa, constituted the starting point for the L. U. B.'s further researches in briquetting.

The following is a list of the binders investigated either specifically by the Board, or indirectly by reference to the work by other experimenters:—

Single Binder: High, medium, or low melting point coal tar pitch, oil pitch, asphalt, lignite pitch, and hardwood pitch: also sulphite liquor, sulphite pitch, etc.

Treated binders: chlorinated or sulphonated tars, oxidized asphalts, treated sulphite pitch (with alkali, or with salts to render insoluble), etc.

Combinations of binders: Combinations of above alone or singly, or in mixtures with the addition of coal tar, lignite tar, hardwood tar, soft asphalts, flour, starch, clay, water glass, cement, straw, etc., with or without the addition of water. Also tests with mixtures of coking coals.

The limits of this report do not permit a discussion of various theories of binder action, voids, moisture action, pressure, etc. It seems better to state as succinctly as possible the general conclusion reached, and give the final results so far as any tabulation can make them of service. It must be remembered that success in briquetting depends on a knowledge of a technique, and this knowledge is practically impossible to tabulate, though general limits and operating data can be so recorded with value to subsequent investigations.

At this point it might be well to note that the Board has in most cases discarded the phrase "percent of binder" owing to its ambiguity,—and has substituted therefore, the phrase "mixing ratio". The mixing ratio is the number of parts by weight of binder added to 100 parts by weight of the carbonized residue. A briquette might be made up of:—

100 parts by weight of carbonized residue.
8 parts by weight of coal tar pitch.
4 parts by weight of sulphite liquor solids.

The Board's method of describing the above binder would be:—

	M. R.
C. T. P.—	8
S. L.—	4. (Solids)

Figure 11 shows graphically the relation between the two systems of recording amount of binder. Figures 12, 13, and 14 constitute a tabulation of the greater part of the Board's early work on briquetting. These figures will give a general indication of the breadth of the Board's researches. In addition, certain briquetting experiments were made on behalf of the Board by outside companies using carbonized lignite supplied by the Board. The quality of their briquettes was decidedly inferior to that obtained in Ottawa, and yielded no information

of great importance. After a constant prosecution of the experiments, and following a thorough exploration of the markets, all but a few binders were next dropped from further consideration. The binders retained for further study were coal tar pitch, petroleum pitches, sulphite liquor pitches, starches, glutens and straw jelly. The last three were considered only as auxiliary binders to be used in conjunction with one or more of the standard pitches.

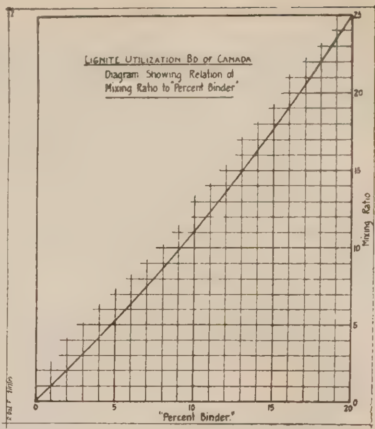

FIGURE 11

By a process of elimination, due to prohibitive cost, petroleum pitches and sulphite pitches were next dropped, at least temporarily, until their price at Bienfait could be reduced, and all attention was concentrated on coal tar pitch, or on combinations of C. T. P. with waste flour screenings. The result was as follows:—

The minimum amount of coal tar pitch necessary when used alone to make a first class commercial briquette as standardized by the Board is M. R. 13. Within certain rather narrow limits, 1 part of weed seed (Waste flour screenings) will replace 2 parts of C. T. P. Thus a very good briquette was produced with

	M. R.
C. T. P.	9
W. S.	2

It is interesting to know that carbonized lignite requires almost double the quantity of binder necessary to produce a briquette physically comparable to one composed of Anthracite fines. This fact alone vitiates many of the conclusions reached by certain writers on the subject who venture to transfer results obtained from anthracite briquetting into the field of lignite briquetting.

During this time also some attempts were made to incorporate as a part binder the pitches that might be obtained during the regular processing of the lignite. This obvious suggestion of so utilizing these pitches was strengthened markedly by the very high cost of C. T. P. binder at Bienfait. Unfortunately the intimate emulsion formed by the lignite tars with water, seemed to render the distillation of the pitch so uncertain that the quality was never uniform. Whatever the cause, the tests on such pitches gave very inconclusive results, and it was decided to give up any hope of using these pitches in the immediate future, with the expectation of attacking the problem later.*

*This was done at the Hebron and Grand Forks tests of Dec. 1923 through the courteous cooperation of Dean Babcock. The matter is referred to later in this chapter and also in appendices 30 & 31.

As the result of these investigations, the Board decided to initiate its work at Bienfait with a straight coal tar pitch briquette.—M. R. 13.

The proximate analysis of the straight C. T. P. briquette made at Ottawa is

Moisture....	4.3
Vol. Matter.	19.4
Ash.........	16.5
F. Carbon....	59.8
B. T. U......	11280

(iv) *Mixers.*

From time to time great claims have been made for the efficacy of paddle mixers and of masticators (sometimes termed edge runners or Chilean mills). Edge runners are installed in a number of plants, and certain of the operators felt that they were indispensible. On the other hand certain other operators reached the conclusion that intimate mixing by paddle mixers was perfectly feasible. Owing to the large cost of these various mixers, it was decided to defer experimenting with them until the main plant was constructed. Examples of each were installed at Bienfait.

v) *Speed of Rolls.*

The rolls of the Board's small press are 2′—0½″ in diameter and were operated at 10-11 R. P. M. making a tangential speed of about 70 feet per minute. These speeds are capable of reasonable variation without impairing the quality of the resulting briquettes.*

vi) *Secondary Heat Treatment.*

The question of secondary heat treatment is one mainly of cost owing to the difficulty of constructing a furnace or a retort in commercial sizes in which the process can be made continuous. The extra handling and capital charges all add naturally to the cost of the finished product, and the question arises,—is the resulting smokelessness worth the cost?

So far laboratory methods go the Board has accomplished the carbonizing by special heat treatment, of several types of briquettes. One of the most interesting examples is a test on a batch of standard coal tar pitch briquettes, M. R. 13. The carbonization of this briquette was made in a large metal retort, immersed in a bath of molten lead. The temperature of the bath was about 500° C. About 5¼ pounds of briquettes were used producing a hard briquette, possessing a smooth surface somewhat difficult to distinguish from the untreated briquette. In this particular experiment the temperature was not quite high enough, and the resulting product showed a slight trace of smoke, but it was very very slight. The treatment of this briquette resulted in a 10% loss in weight.

After being allowed to stand for two days, the treated briquettes were analyzed with the following result:—

	%
Moisture........................	2.9
Volatile Matter.................	8.3
Fixed Carbon....................	72.3
Ash.............................	16.5
B. T. U. per lb.................	11760

*It is interesting to note that the relation between diameter of rolls, size of pocket and tangential speed vary very markedly depending on the material that is being briquetted. For example, conditions that would be correct for coal briquetting are quite inapplicable and unsuitable for the briquetting of flue dust. A considerable field of research is here open.

After considerable time had been spent in weighing the advantages, cost, etc., of smokeless briquettes, it was decided to postpone further investigations until such time as the main plant would be in operation, and a commercial briquette was actually on the market.

vii) *Briquette Testing.*

The various tables on briquetting previously mentioned in this section have summarized the results of many of the tests conducted. There were however, certain other tests which may be of interest.

In order to ascertain the probable behaviour of briquettes in the extremely cold western weather, certain typical examples were subjected to freezing and thawing tests. These were conducted in the sharp freezer of the Wm. Davies Co., Limited, Montreal, through the courtesy of the officials of that company. Tests were run as follows:

The briquettes were first immersed for 24 hours in water and then placed in the sharp freezer for 24 hours. The temperature of this was from 0°F to minus 12° F. After 24 hours in the freezer the briquettes were removed and thawed out for 24 hours in water. This alternating treatment was continued for four complete cycles, and a close examination was made of the briquettes. On the briquettes that the Board classified as good and water proof, no signs of deterioration were visible whatever. It will be admitted that this test is a very much more severe one than any natural freezing or thawing could be.

The foregoing is a brief summary of the briquetting results achieved in the Ottawa laboratory.

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During the conduct of the above mentioned researches in Ottawa during 1919-20, the Montreal office was busy preparing the designs of the main plant. Necessary approximate sizes of apparatus, approximate dimensions, and the general space requirements for the dryer building, the carbonizer building, power house, and in fact for all buildings, with the exception of the briquette building, were obtained and were available for use during the design of the plant. But information necessary to design the briquette building intelligently and economically was practically impossible to obtain so quickly. It therefore became necessary to make a very rough approximation of the space required for briquette machinery etc., in order to allow the contract to be prepared and awarded in the spring of 1920, and then at a later date the detailed layout of briquetting machinery could be made. In other words to save a delay of perhaps 12 months, it became necessary to fit briquetting machinery into an existing building design, rather than to enclose a machinery layout with building walls. This is one of the reasons for the subsequent difficulties with layouts, because the resulting crowded condition of the machines gave rise to some bad drives and sequences.

In the report of Stansfield and French mention is made of the courteous co-operation offered by the General Briquetting Co., New York. One of the plants designed by this company was that of the Nukol Fuel Co., Toronto. After correspondence, permission was kindly given for a comprehensive inspection and test of this plant — provided no inter-

ruptions were made to the throughout or general operation. This permission was accepted, and in April 19, 1920, R. A. Strong and Hammond Johnson, members of the Board's engineering staff, reported in Toronto, and spent over a week at this plant.

Upon the conclusion of the test at the Nukol Plant, a brief inspection of the Anthracite Briquette Co's plant, Toronto, was made. No tests were possible at the plant, and the information recorded was gained by the inspection only.

The conclusions of the Nukol plant test may be summarized as follows:

(i) Washing of this particular coal at point of origin might easily pay for itself by reduction of ash content — a worse then useless ingredient.

(ii) Alleged efficiency of edge runner not proven conclusively.

(iii) A probable relation exists between briquetting temperature and density of briquette.

The full details of this test and inspection are covered by a report of Strong and Johnson appearing as appendix No. 28.

As a result of the accumulated information then in hand in regard to briquetting, it became necessary:—

(a) To decide on number and sequence of briquetting units.
(b) To design binder feed equipment and layout.
(c) To prepare the layout of machinery.

After considerable thought, it was decided that the briquetting machinery would consist of the units below mentioned. The inclusion of them all in one plant was not due to any strong conviction as to the outstanding merit of any one of them, but rather the feeling that the Board would be negligent if it omitted to give full scale tests of each of the types in view of the large claims made by various operators. It was felt also that if any one unit proved a failure or too expensive in operation, it would be a comparatively simple and not a costly change to by-pass it in the process.

The binder system was laid out as described below, and reports on it appear later in this section.

The layout of the various units now definitely accepted for inclusion in the process, brought in its train intricate problems, to aid in the solution of which the Board retained as Consulting Engineers, the General Briquetting Co., New York, the leading authorities on this continent. It was arranged with this company to second to the service of the Board, for as long as necessary, one of their briquetting engineers selected by themselves especially for this work. This was done and in due course a layout was prepared and submitted. Upon close examination by the staff, several improvements in it were suggested, and it was decided to have the Board's staff prepare an alternative revision. This revision was completed in the Spring of 1921, and the two layouts were very carefully compared from every point of view. It was then decided by all parties to adopt the revised layout, which appears in figures Nos. 18 and 19.

The following is a detailed description of the Bienfait briquetting plant and binder system, as originally erected in 1921. — Subsequent changes are referred to in appendices.

The mixing and briquetting equipment consisted of:—

2 — Type M-1 ten ton horizontal steam jacketed mixers, manufactured by the Mashek Engineering Company, New York. One of these is used as a tempering mixer.

1 — Vertical fluxer 42 inches by 8 feet, manufactured by the Traylor Engineering Company.

1 — 15 ton 8 foot diameter masticator manufactured for the General Briquetting Company, New York.

1 — 15 ton Belgian roll press — rolls 26½ inches in diameter by 11½ inches face containing 6 rows of ovoid moulds with 36 moulds to one circumference. The weight of the briquette produced is approximately 2 ounces. The press was manufactured by the Gilley Machinery Company, Gilley, Belgium.

The routing of the material may be traced by referring to plan view of briquette building shown in Fig. 19, and to section DD, appearing Fig. 18.

The carbonized residue is taken from the base of a large steel pyramidal bottom bin, and passes directly through a short conveyor (No. 20) to the first horizontal paddle mixer (No. 21) into which the coal tar pitch binder is run. The control of the binder will be described in a succeeding paragraph.

Passing through mixer No. 21, the mixture is fed to a vertical fluxer (No. 22) which discharges directly into the edge runner (No. 23) (chilean mill). From the edge runner (No. 23) it passes through a short conveyor (No. 24) to the tempering mixer (No. 25), which is steam jacketed and capable of controlling the temperature of the whole mass. From there it is hoisted by a vertical conveyor (No. 26) and discharged into the main press (No. 27). After being formed the briquettes pass over a shaking screen (No. 28) which removes all fines and broken parts, and returns them by means of a special inclined chute to the tempering mixers (No. 25). The good briquettes are passed over the screen (No. 28) and slide down a series of inclined chutes to a cooling conveyor where they are cooled under air draft. This long conveyor (No. 29) operates through an underground tunnel connecting the briquetting building with the storage bin. This tunnel is cooled by forced draft operated by a 7½ H. P. motor connected to a fan discharging 20,000 cubic feet of air per minute, and which was arranged so that every briquette will be on the belt for at least 4 minutes subject to high velocity air cooling. The two mixers and the fluxer are thoroughly provided with ventilating ducts, shown clearly in section DD, which permit ample ventilation for excess steam, or any gas, etc.

The binder is delivered to the plant in tank cars which are emptied by gravity into an underground concrete storage reservoir. The pitch used has a melting point of 140°F. usually determined by the cube method. The storage tank possesses steam coils at its bottom in order to keep pitch fluid. The binder is pumped to a small

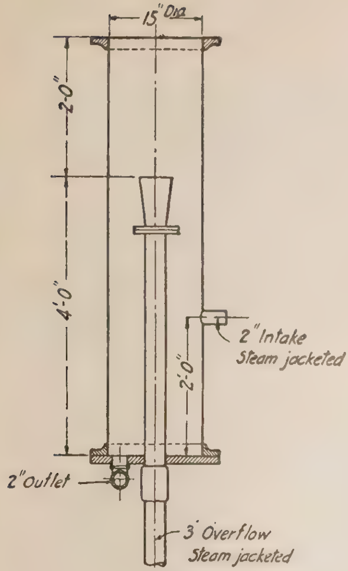

FIGURE 63

overhead control tank, made from section of 15″ black C. I pipe — 6′-0″ high. This tank is fed by a 2″ feed pipe, opening into the tank at a point about 24″ from the bottom. The discharge pipe is also 2″ in diameter, and leads from the bottom of the tank.

In order that the control of quantity of binder should be as simple as possible it was decided to limit it to one valve, and in order to insure a constant discharge, arrangements were made so that that the pitch would be kept at a constant temperature (giving constant viscosity) and operate at a constant head (giving constant pressure). Uniform temperature was to be obtained by having all binder piping steam jacketed. A uniform head is obtained by providing the control tank with a bell mouthed 3″ overflow pipe, the lip of which is 48″ above the bottom. By this means a head of 48″ will always be operating in the discharge pipe. The details are shown in Figure 63.

The control valve in the discharge pipe was to be calibrated empirically after plant had been in actual operation.

The foregoing constitutes a description of the briquetting plant as designed, and the construction of it was completed in August 1921.

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The trial runs of this equipment during 1921 and 1922 are recorded by R. A. Strong in appendix No. 23.

As disclosed therein the layout of the machinery is faulty, and parts of the binder circulatory system unsatisfactory.

The faults and difficulties may be recorded as follows:

Summary of mechanical disadvantages of present briquetting layout, from point of view of briquetting lignite char.

(1) The arrangements for feeding char to 1st mixer are not capable of sufficiently accurate adjustment.

(2) There are not sufficient means for controlling temperature of char before coming in contact with the binder.

(3) There is no provision for crushing the char before mixing with the binder. This point has been due to recent decision to omit edge runner.

(4) The vertical fluxer has been proved to be not suited for mixing lignite char.

(5) The edge runner has proven not entirely satisfactory for such soft materials as lignite char, and should be omitted in subsequent development.

(6) Any system involving a lifting of the mix from the last mixer to the press is not entirely satisfactory, and should be avoided.

(7) The shaker screen with drop to cooling table, constitutes too severe a method of handling fresh briquettes.

(8) Gravity flow of pitch to mixer is not satisfactory, as quantity is not subject to accurate control.

As a result of these apparent weaknesses, the Board recommended in March 1923 to the supporting governments, that the briquetting layouts be amended, that certain changes be effected in the binder system, and that in general, the briquetting plant be placed at the earliest date in an operating condition, in order that when the carbonizer difficulties had been solved* the whole plant would be ready to operate without further delay and thus eliminate carrying charges on a shut down plant. But by the terms of the understanding reached at Winnipeg March 3, 1923, the Board was precluded specifically from making any expenditures on, or alterations to an equipment with the layout of which they were by then quite dissatisfied. This recommendation regarding revisions to briquetting layout was urged again on the governments at the July 30 meeting in Winnipeg,[1] and again in the memo of September 14,[2] deposited in Ottawa. In each case however a negative decision was given by the governments.

Acting on the express instructions of the governments the Board next made arrangements with Dean Babcock, University of North Dakota, for two briquetting tests on carbonized lignite produced at the Bienfait plant by means of the Hood-Odell oven. It was felt by the governments that it would be desirable to test the applicability to briquetting of the char from the new oven. It was therefore arranged by the Board with Dean Babcock to undertake at the earliest date two tests:—

i) At Hebron plant N. D.	125 tons of standard vol. char. 25 " " high vol. char.
ii) At Grand Forks N. D.	Small one ton tests to explore variables such as low volatile char, use of lignite pitch produced by distilling tar from Hood Odell oven.

The layout of the plant at Hebron[3] is covered by a special report of R. A. Strong which appears as appendix No. 29, and the result of the tests at Hebron are covered by another report of Strong's appearing as appendix No. 30. These tests may be summarized as follows :

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*As then seemed imminent and as subsequent events proved to be true.

1 See appendix No. 13.

2 See appendix No. 14.

3 Further information on the Hebron plant and its very important work can be found in Bulletin No. 221 of the United States Bureau of Mines entitled "Production and Briquetting of Carbonized Lignite" by E. J. Babcock and W. W. Odell.

OBJECTIVES.	RESULTS.
(a) To determine whether the char as produced from the vertical shaft oven erected at the Bienfait plant would present any peculiar difficulty in briquetting.	(a) No serious mechanical difficulties were encountered during the test and a satisfactory grade of briquette was produ ed.
(b) To determine whether a satisfactory briquette could be produced from a char containing a somewhat higher volatile content than that ordinarily produced.	(b) No mechanical difficulties were encountered in producing a high volatile briquette although these briquettes did not appear to be as good physically as those with a low volatile content.
(c) To determine whether lignite pitch as made from the lignite tar recovered in the operation of the Hood-Odell oven at Bienfait could be utilized as a binder.	(c) Lignite pitch was incorporated with the coal tar pitch in a ratio of 20% of lignite pitch, and the briquettes produced were equally as good as those made with coal tar pitch alone. This is an important result.
(d) To obtain all information possible in regard to plant operation.	(d) Accurate records were kept of all possible variables in the plant such as speeds and temperatures.
(e) Make all necessary tests to determine the quality of the briquettes produced.	(e) The test on briquettes included, — analysis of raw material, — analysis of final product, — drop tests, — and stove tests. In connection with this last mentioned test, comparison is made between the lignite briquettes and Anthracite coal on a basis of degrees hours. This somewhat new but important method of comparing fuels affords very interesting results.

The record of the tests at Grand Forks is covered by a special report prepared by R. A. Strong — appearing as appendix No. 31, and may be summarized as follows:

(1) A two ounce briquette is superior to a 4 ounce briquette as a greater pressure is obtainable with the smaller size. (This applies to the product of roll presses only).

(2) Two sets of rolls are preferable in crushing as a more uniform screen analysis is obtainable and this results in a better briquette.

(3) Binder requirements are dependent on volatile content of char. The higher the volatile the more binder required.

(4) High volatile briquettes are not as strong in the fire as those made from low volatile char.

(5) Lignite pitch can be mixed with coal tar pitch and thus utilized as a binder.

(6) Briquettes made with lignite pitch alone are not as strong as those made with the mixture of coal tar pitch and lignite pitch.

(7) The use of lignite pitch tends to eliminate dust in handling briquettes also decreases tendency for the mix to stick in the press rolls.

(8) The char as produced in the vertical retort installed at Bienfait does not offer any new problems in briquetting.

The report of the Hebron and Grand Forks tests must not be closed without recording an especial word of appreciation of Dean Babcock's unfailing courtesy and co-operation, for which the Board is more than grateful.

In any work of this character, it is inevitable that a great many attempts would be made to persuade a semi-public commission to adopt this or that "process". Some of the processes or methods thus suggested are good and extremely useful, — others less so. The experience of the Lignite Board does not provide any exception to the situation and no record of the briquetting work would be complete without stating that the following briquetting processes have been investigated, either slightly (due to small amount of time at disposal, or to reluctance of owners to place their cards on the table,) or more completely in other cases. Some of the ideas and methods presented have great merit.

General Briquetting Co.	New York.
Sheehan Process.	Seattle, Wash.
Fournier Process.	France.
Treadwell Process.	New York.
Laing Process.	New York, Winnipeg, and other cities. Called to our attention by a number of different representatives at various times.
Oliver Process.	Edmonton.

In connection with all these matters, the Board would observe that it has already developed successfully a technique of carbonized lignite briquetting, but wishes to record its appreciation of the co-operation so often extended by other investigators above noted. The General Briquetting Co., (Mr. A. L. Stillman, Vice President) New York should be noted especially. During the time of the Ottawa work, Mr. Stillman and his company made a number of extensive briquetting investigations on carbonized lignite, which proved of real value to the Board.

It has already been noted that 150 tons of lignite briquettes were made at the Hebron plant of the University of N. Dakota. Of these briquettes, one carload lot was forwarded to each of the supporting governments in order that they might be tested by a large number of individual non-technical consumers, whose opinion of their marketable qualities would be of great value. 100 lb. samples were distributed by the Saskatchewan government immediately upon receipt of the car, to members of the government, members of the legislature, members of the press, and other leading citizens. At date of writing this report it has only been possible to obtain opinions from a few recipients of these samples, but through the courtesy of Mr. T. M. Molloy, the Board has received copies of their written views. These make intensely interesting reading, and may with fairness be digested as follows:

For use in cook stoves and open grates.	All unanimously of opinion that carbonized lignite briquettes are a wonderful fuel.
For use in furnaces.	Great majority are enthusiastic but some find excess of ash or clinker, but all admit sample was not large enough for a thorough test.*

*The scientifically managed stove tests referred to by R. A. Strong in appendices 30 and 31 are however of even greater value in reaching an estimate of the ultimate suitability of these briquettes for domestic consumption.

SECTION IX

FINANCE

CONTENTS

It is proposed in this Section to treat the following subjects:

(a) The relation of the ultimate total expenditure to the original estimates, and reasons for the large increase thereof.

(b) An analysis of the total expenditure of the Board.

(c) An analysis of the cost of the plant.

(d) Methods of bookkeeping, accounting, and reporting to Governments.

(e) Estimate of commercial feasibility of the whole project from financial point of view.

DISCUSSION ON (a) — *The relation of the ultimate total expenditure to the original estimates, and reasons for the large increase thereof.*

Upon starting operations the Board had financial resources in the sum of $400,000 half of which was supplied by the Dominion and one-quarter by each of the two Provincial Governments of Manitoba and Saskatchewan. From 1919 onward additional grants have been made:–

	YEAR	AMOUNT	
Original grant	1918	$400,000	
			$400,000
Special additional appropriation	1920	$280,000	
Special additional appropriation (net)	1921	137,500 (*approx.*)	
Special additional appropriation (net)	1922	218,800 (*approx.*)	
			$636,300
Grand Total			$1,036,300

In all these payments, with the exception of the last named, the three supporting Governments maintained the original ratio of distribution — one half by the Dominion and one quarter each by the two Provinces.

It now remains to enquire why this startling increase — an additional sum of nearly 1-½ times the original amount? Was it a case of bad estimating or inefficient administration? These questions can be answered completely by a detailed consideration of the additional estimates; and for convenience they will be named and referred to by the year in which they were granted.

The 1920 and the 1921 additional estimates were made necessary by the following causes:—

i) The original estimate of $400,000 was made by the Fuel Committee of the Research Council (see Fig. No 15) in 1917. Board was founded in 1918. Fundamental research delayed Board about a year. Thus construction was prosecuted from 1920-1921 at the very *peak* of material and labour prices, a time unprecedented in construction difficulties and costs.

ii) In the original estimate no provision whatever was made for importing civilization to plant, as location was quite impossible to determine at that time. Ultimately the sum of approximately $118,000 was spent on housing, and the sum of about $36,000 on sewage and water supply plants.

The 1922 appropriation was occasioned by the fact that it was necessary to make an extensive reconstruction of the carbonizing and gas handling equipment* and to supply working capital for purchase of coal, binder and wages, etc. The combined requirements amounted to $250,000, one-half of which $125,000, was granted in 1922, and the remaining half in 1923. Of this latter amount, however, one-quarter ($31,250) was returned by the Lignite Utilization Board to the Receiver General owing to the fact that Manitoba in September, 1923, withdrew her support from the project. (See Section VII).

It now remains to discuss consecutively and in some detail the reasons which made it necessary for the Board to ask for these appropriations.

1920 Appropriation of $280,000.

The principal reason for the increases necessary was, as already mentioned, the increase in the cost of material and labour between the years 1917 and 1920-1921. This advance was simply unprecedented, and the years 1920-21 marked the most difficult and expensive period for construction ever experienced. To illustrate this increase the original estimate of cost as presented by the Research Council in 1917 and the estimate as prepared by the Board in May 1920 are shown respectively in columns 1 and 2 of figure 15. It will be noted that in the Research Council estimate, there is no provision whatever for bringing civilization to the plant (houses, sewers, water supply, etc. as it was contemplated that plant would be in some town). Column No 3 of the same figure shows the estimate of prices prepared by the Board in May 1920 to cover cost of purchase of exactly the same plant, had construction been undertaken during the first quarter of 1917. A perusal of this figure will show clearly that the plant as designed in 1919-1920 was not out of scale with or more elaborate than the plant originally contemplated by the Fuel Committee of the Research Council.

The total of column No. 2 figure 15 is $675,000. This figure included a provision of a sum of $75,000 for housing (which afterward proved to be very much less than was required) and a very small amount for working capital. The excess of this total figure $675,000 over the

*For necessity of this step see Sections V and VI Pp 47-51.

original appropriation was approximately $280,000, and the request for this additional increased amount of money was laid before the Hon. Arthur Meighen, the then Minister of Mines, in a special report dated May 25th, 1920. The three participating Governments agreed to pay their respective shares of this amount by a tripartite agreement dated Nov. 12, 1920 and upon the signing of the agreement, the Dominion Government released its share of the appropriation by forwarding the sum of $140,000 on January 21st, 1921. The other amounts were paid subsequently by the two Provincial Governments.

1921 Appropriation of $137,000. (Approx)

By May, 1921, the completion of the plant construction was well within view, and it was naturally expected that operation would be started without any undue technical difficulties other than the usual incipient troubles always disclosed when placing in operation a plant composed of many departments or processes. It became apparent in April that the amount of money available from the original grant of $400,000 plus the 1920 grant of $280,000, would not be sufficient to complete the capital construction, and in addition no adequate provision had been made in either of the original appropriations for working capital. Owing to the fact that the Board expected at least a period of three months with no reasonable return from sale of briquettes, and owing to its desire to have an ample reserve of working capital, a request was submitted to the Dominion Government on May 23rd, 1921, for a further appropriation in the amount of $140,000. The negotiations following this request were long and arduous. As before, the Dominion Government took the position that each of the supporting provincial Governments must become a party to a new agreement, (which would embody their respective responsibilities), before any question could be entertained of releasing the money. In addition the Minister of Mines took the precaution of ordering a special investigation into the commercial aspects of the venture by Walter E. Segsworth, Esq., M. E. This report was presented to the Minister sometime in August, 1921, though the contents of it were carefully withheld from the Board for a period of over two years. During these long drawn out negotiations the cash resources of the Board were getting lower and lower. Owing to the uncertainty of the situation it was not felt possible to assume the most ordinary obligations, and by the beginning of September the position was indeed precarious. Carbonizer operation had started, but the Board had not sufficient money to purchase insurance against fire or explosion, nor had it enough to buy fire hose or nozzles, pyrometers, or other scientific instruments necessary for the proper control of the tests. The increasing gravity of the situation was realized finally by the Government, and on September 28th, their cheque was received for the sum of $137,542.96. This appropriation was earmarked for expenditure by the Board roughly as follows:—$100,000 for working capital and operating expenses, and $35,000 for capital charges necessary to complete plant construction.

1922 Appropriation of $250,000.

By the late autumn of 1921, it became apparent that the financial resources of the Board would be barely sufficient to bring to a close the

carbonizer runs then being held.* The foregoing paragraph has indicated that the 1921 grant of $137,000 was earmarked to be expended as follows:

Operating and working capital.......	$102,000
Capital..........................	35,000

Toward the close of the year 1921 it was seen that this $137,000 would have to be expended as follows:

Operating Expenses.................	$ 42,000
Capital Charges....................	94,000

This made an overrun on capital expenditure of about $55,000 beyond the estimate of 1921. This large difference was due to an error in estimating total capital requirements on plant buildings, housing and equipment. This serious error is deeply regretted, even though it amounts to only 7.8% of total cost of plant, housing and machinery.

As a result then of the extra capital requirements, and as a result of the increased time taken in attempting to get the plant in an operating condition, the Board found its finances practically exhausted at the end of 1921. This coincided with the technical crisis in the carbonizers, and it therefore became necessary to prepare a thorough estimate of cost of reconstruction, cost of operating, and amount of working capital required. These matters were gone into in considerable detail, and an amount of $250,000 determined upon. After a number of informal discussions with the Dominion Government, a formal report on the matter was submitted to the Minister of Mines on January 20th, 1922. The matter was next discussed with the two provinces and their consent obtained.° The Dominion Government was then approached again, and a report† was submitted dated February 22nd, 1922. On April 15th, 1922, the Federal Government had concluded a new agreement and paid over to the Board the half amount $125,000 asked for immediately.

This half appropriation met all the expenses of the Board during the next 11 months (April 1st, 1922 — March 1st, 1923) for all purposes, carbonizer and gas system reconstruction, normal operating expense, and cost of all trial runs during autumn of 1922, and finally the cost of the special Hood-Odell oven test at Grand Forks, N. D. during February, 1923. At the close of this eleven month period there remained a sum of approximately $23,000 and the Board was instructed to expend this amount in building and operating one of these Hood-Odell ovens at Bienfait. At the same time the signing of a fifth agreement‡ between the three supporting Governments made possible the payment of the remaining half appropriation ($125,000) to the Board on April 30th, 1923. This total of $148,000 has enabled the Board to build one Hood-Odell oven at Bienfait during May and June, 1923, operate it for a period of 6 months, conduct special briquette runs at Hebron, N. D. during December, 1923, return $31,250 to the Manitoba

*The general situation is described in Section VI pp. 50 and 51.

°See Section VI pp. 51 and 52.

†See appendix No. 10.

‡Dated March 10, 1923.

Government, pay all operating charges, and still hold a balance of about $58,000 at Jan. 1st, 1924 exclusive of those monies accruing to the Board from house rentals and special services.

b) *Analysis of Total Expenditure.*

It is proposed in this section to present a bird's eye view of the total expenditure of the Board from a number of angles.

The receipts of the Board have been:

RECEIPTS	Oct. 1st 1918 — Dec. 31st. 1923 *Approx.*	
From Governments	$1,036,300	
" Misc. Sources	13,900	
" House Rentals and Special Services a/cs	9,500	
		$1,059,700

The expenditure is first presented under the same heads as were used to keep the Government officials in touch with the financial aspects of the work. These are:—

EXPENDITURE:—	*Approx.*	% of Total Receipts.
Engineering and Administration	$141,600	13.3
Travelling	12.800	1.2
Capital Expenditure — Plant	604,700	57.1
Capital Expenditure — Housing	117,700	11.1
Operating Expenditure and Maintenance and Repairs	107,200	10.1
Miscellaneous	8,300	0.7
	$992,300	93.5%

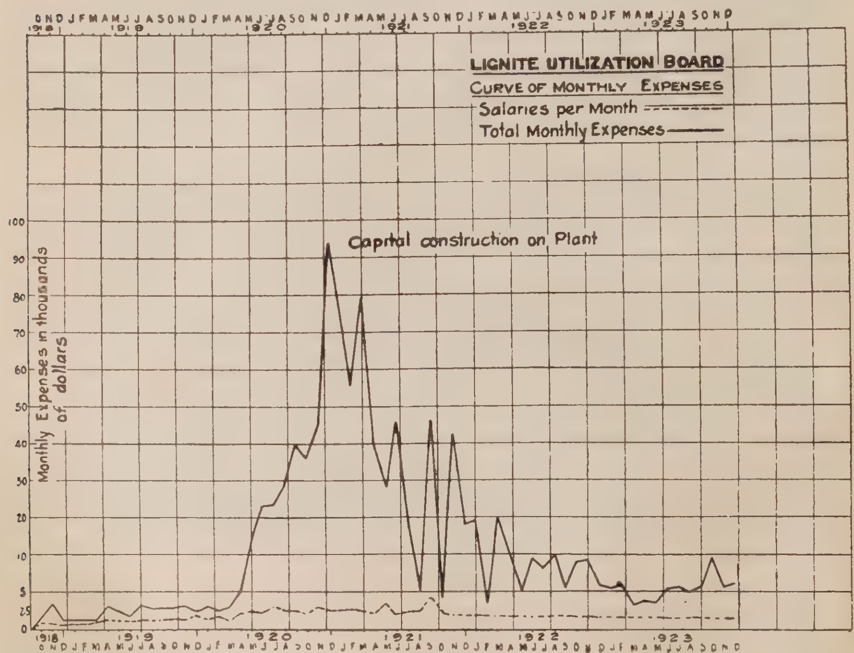

FIGURE 16

The relation of this expenditure to time and date is shown by graph in Fig. 16.

A glance at the foregoing figures will make evident the absurdity of the million dollar plant rumour so frequently heard during the discussion of this project. The total capital amount invested in the plant itself amounts to only $604,700 including the Hood-Odell oven and accessories. The remaining portion of capital appears under housing, etc. Coming now to an analysis of these various general heads the total of engineering administration is $141,600. This is broken up as follows:

Office supplies, Stationery, Printing Blue Prints, Tracing Cloth, Routine Telegrams, Miscellaneous Office Expenses	$ 7,223.00	
Rent, Light, Taxes, and Insurance	6,200.00	
Petty Cash	1,292.00	
Salaries	113,435.00	
Reports, Investigations, Legal Fees and Bonding Costs	13,450.00	
		$141,600.00

In connection with salaries in the foregoing list, it is to be noted that not one cent of salary has been paid to any member of the Board. Their services have been entirely honorary from the beginning to the end of the whole project. It is to be noted also that total administrative expense including engineering on whole programme, (much of which was experimental and some of which was occupied by marking time) is only 13.4% of total receipts.

The total travelling expenses need no comment.

Plant capital expenditure is approximately $604,700, and this amount is analyzed completely in the next section of this chapter.

Capital expenditure in Housing can be divided as follows:

Boarding House	$31,400.00	
Houses	86,300.00	
		$117,700.00

Operating expenditure totals $107,200 and can be divided as follows:

Stores a/c	$ 5,500	
Insurance and Taxes	17,500	
General Operating, Bienfait, and Experimental Operating at Grand Forks and Hebron	72,000	
Hood-Odell Operating and Repairs, Bienfait	12,200	
		$107,200

The Miscellaneous account is not large enough to need any special comment or analysis.

c) *An Analysis of Cost of Plant.*

The total capital expenditure on plant was $604,700. Fig. 6 shows the flow sheet diagram, in which appear subdivisions A, B, C, D, etc., especially for accounting purposes.

The complete analysis of this total by divisions appears:—

CAPITAL COSTS.

	BUILDING	EQUIPMENT	TOTAL
A. Raw Lignite Handling.......	$ 24,860.00	$27,900.00	$52,760.00
B. Drying....................	27,250.00	53,500.00	80,750.00
C. Carbonizing................	54,500.00	65,000.00	119,500.00
D. Mixing and Briquetting.....	38,630.00	47,400.00	86,030.00
E. Storage and Unloading......	11,600.00	2,750.00	14,350.00
F. By-Product Recovery.......	1,540.00	40,550.00	42,090.00
G. Yards and Switches.........		13,650.00	13,650.00
H. Water Supply and Drainage..	11,670.00	36,750.00	48,420.00
J. Power and Power House....	23,730.00	67,750.00	91,480.00
K. Office and Laboratory......	18,380.00	7,570.00	25,950.00
O. Machine Shop Equipment...		5,530.00	5,530.00
P. Small Tools Equipment.....		1,830.00	1,830.00
Temporary Buildings........	4,720.00		4,720.00
Auto Equipment...........		2,380.00	2,380.00
Fire Protection Equipment..		860.00	860.00
House Property Equipment..		680.00	680.00
Boarding House Equipment..		2,930.00	2,930.00
Pipe Line..................		3,990.00	3,990.00
Office Equipment and Library		1,950.00	1,950.00
Hood-Odell oven...........		4,850.00	4,850.00
	$216,880.00	$387,820.00	$604,700.00

A glance at the foregoing table will show that the sum of about $60,000 was spent originally on the 6 carbonizers. Assuming a cost of $10,000 for each one, it is seen that the amount risked, say $40,000, in building a full battery of six instead of two would soon have been eaten up in overhead had any long waits resulted.

A further analysis of plant costs appears in appendix 44 which gives the ledger totals referred to below.

d) *Methods of Book keeping and Accounting.*

At the inception of the work it was desired to present monthly statements to the interested Governments that would give quickly and briefly a clear view of the expenditure during the month. For that reason four main departments of expenditure were recorded and sub-heads under these were adopted as follows :

A — *Engineering Administration*

A10 Office Supplies, Stationery, Printing, Blue Prints. Tracing Cloth, Routine Telegrams, Miscellaneous Office Expense.
A11 Rent, Light, Taxes, and Insurance.
A12 Petty Cash.
A13 Salaries.
A14 Reports, Investigations, Legal Fees and Bonding Costs.

B — *Travelling:*

B20 Members of Board.
B21 Members of Staff or Agents of Board.

C — *Capital:*

C30 Office Equipment and Library.
C31 Land or Bldgs. Special Construction, Mach'y and Instruments.
C32 Premium and Exchange on Capital Account.

D — *Miscellaneous:*

D40 Miscellaneous.
D41 Interest and Exchange.
D42 Contract Deposits Returned.
D43 (Hon. Advisory Council for Scientific and Ind. Research) · Loan Returned.
D44 Transference to Dom. Government of Moneys on Deposit from Manitoba.
D45 Refund Dom. Government account of Manitoba withdrawing.

This system of keeping track of the expenditure was followed until the construction period was reached when more elaborate methods were installed. Whereas formerly the work had been confined entirely to a columnar cash book, with the advent of construction the following set of books were opened—

Voucher Cheque Register
Cash Book
Journal
Ledger

the change taking place at May 31st, 1920. In order that the continuity of the monthly reports to the Government should not be broken it was decided to lump all the capital and operating expenditures into account No. 31 until such time as commercial production had been attained. In this way the Government officials interested would receive as heretofore the same type of monthly accounts, and these would be of more value to them for comparative purposes if no change were introduced. The ledger accounts are of interest as indicating the thoroughness with which the Board is prepared to analyze the capital and operating charges of the plant once commercial operation were in full swing.

The table appearing in appendix 44 gives a complete record of the ledger accounts as at January 1st, 1924, showing the respective balances. These figures give, of course, a detailed analysis of the total cost of the plant and subsidiary enterprises.

By the terms of the first agreement between the three supporting Governments (See appendix No. 2) the Dominion Government had the right to appoint the auditor of the Board's work, and shortly after the inception of the enterprise notification was sent from Ottawa that the Auditor General of Canada would discharge this function. The first audit of the Board's books was made in May, 1920, and a very favourable report was received at that date and upon each subsequent audit. In order that the Auditor General might be kept as intimately in touch as possible with the progress of affairs, each month there has been sent to him as follows:

(a) A statement of expenditure of the preceding month.

(b) A statement of expenditure from the beginning of the financial year to the close of the preceding month.

(c) A statement of the total expenditure from October 1st, 1918, to the close of the month under review.

(d) A list of all cheques issued by the Board during the preceding month.

In this way the auditor was thoroughly *au fait* with every expenditure made by the Board, with the methods of Book keeping installed, the safeguards maintained for payments of accounts, etc., and the Board wishes to take this opportunity of recording its appreciation of the universal courtesy and consideration extended by the Auditor General and his representatives during the course of the work.

(e) *Estimate of commercial feasibility of the project from financial point of view.*

Now that a process of carbonizing and briquetting low grade lignites has been developed successfully it only remains to give a commercial demonstration of the project on a cost basis in order to realize completely the original objective enjoined by Dominion Order-in-Council.

The cost of converting commercially more than two tons of lignite into one ton of briquettes, is one that can be really determined only when operating a fair sized plant over a reasonable period of time. Anything else is mere estimating, though it is an indication of what may be expected in a favourably located plant. It must be clearly pointed out also that the costs of a true commercial plant erected with all the knowledge now available, and the costs determined at the Bienfait plant (with its necessarily large investment in permanent buildings, etc.,) are two very distinct matters.

W. W. Odell in a U. S. Bureau of Mines publication, serial No. 2,241 dated February 1923, under title of "Report of Lignite Carbonization Experiments Conducted at Grand Forks in 1922" states that the cost of making a briquette under certain definite assumptions is $8.17 per ton. This is without profit, with a fair allowance for plant but with very little allowance for buildings. Dean Babcock and W. W. Odell in Bulletin No. 221. U. S. Bureau of Mines, entitled, "Production and Briquetting of Carbonized Lignite" give an estimate of $9.00 per ton exclusive of profit, with an allowance of $250,000 for buildings and plant, etc. The Lignite Board believes that both these figures are on the low side for Western Canadian conditions, for two reasons, (a) the assumed cost of lignite coal is below what a suitable type of coal can be purchased for in Bienfait to-day. (b) In the opinion of the Board the allowances for depreciation and other kinds of overhead are not sufficient.

The Board would suggest therefore, that the figure of $9.50 to $10.50 per ton of briquettes, exclusive of profit, would represent a closer cost figure on a 35,000 ton per annum plant, the location of which was economic from points of view of supply of raw material, water, shipping, etc. This figure could, however, be greatly reduced with a

200 ton a day plant, (60,000 to 75,000 tons per annum) also favourably situated as regards coal, shipping, water supply, etc. The Board confidently believes that this figure could be still further reduced by the use of the lignite pitch as a portion of the binder, and by the sale of oils, recovered by the distillation of the tar from the Hood-Odell oven (see appendices 25 and 27).

This figure of $9.50 — $10.50 is submitted also as an indication of what can be attained even at the Bienfait plant if the following be done in order to put the plant on an operating basis:—

a) Write off a certain amount of the capital already invested, because of the lower construction costs since the peak days of 1920-21, and because of accurate determination now made that certain machines and processes are no longer necessary.

b) Effect changes in yard trackage, sewage disposal, switching, water supply and build ten new carbonizers, dismantle old ones, and revise briquette building.

The figure given above is of course made up of two portions:—

i) Cost of actual physical material in the briquette.
ii) Labour, overhead, repairs, depreciation, interest and the like.

The first of these two can be determined very accurately without further operation, and is as follows, subject to the stated assumptions.

Assumptions	a) Proximate analysis of briquette	5% Moisture 10% C. T. P. Binder 2% Flour Binder 83% Char.
	b) Raw lignite at $2.00 per ton at plant, and 42% yield in carbonizer.	
	c) C. T. Pitch at $20.00 per ton at plant.	
	d) Flour at $25.00 per ton at plant.	

Char — (carbonized lignite)	$4.00 per ton
C. T. P. Binder	2.00
Flour Binder	.50
Total Cost of Materials in briquette	$6.50 per ton.

The second of these two general items of cost can only be determined by actual commercial operation, as it must include direct labour, management, insurance, workmen's compensation, interest and depreciation, repairs, taxes, and contingencies. An estimate for this item of $3.00 to $4.00 per ton brings the cost figure per ton up to $9.50 to $10.50 without profit.

SECTION X

MISCELLANEOUS

CONTENTS

Relation of Lignite Board's Effort to Carbonize Lignite to the Efforts of Similar Character Elsewhere.

The foregoing sections of this report have been devoted to the task of visualizing and recording the efforts made during a period of five years to give a commercial demonstration of a process of carbonizing lignite and briquetting the char in order that the whole process might become available for subsequent commercial exploitation. This point has been stressed repeatedly. In the prosecution of this specific task over one million dollars have been expended, and as noted herein, the work is still incomplete. It is therefore pertinent to submit two very searching questions:—

(a) Is the objective if and when attained worth reaching? In other words has the Board been engaged on a useless enterprise?

(b) Have the expenditures been entirely out of scale with the magnitude and importance of the desired results?

The foregoing questions can be best answered by a clean cut statement of what has been attempted by both private corporations and governmental agencies elsewhere. If such a recital discloses that many large concerns have devoted years to the pursuit of a similar objective, and if it can be shown also that the expenditure by such bodies has been very large, then it is apparent that the Lignite Board's project has not been an abortive effort entirely out of step and out of scale with the rest of the world. For example, there has been a feeling in the minds of many that, as the Lignite Utilization Board venture was a government undertaking, inefficiency and extravagance must necessarily have accompanied all its activities. The simplest way to answer the above mentioned questions, and at the same time to place the work in a proper perspective with what has been undertaken elsewhere, is to present a brief digest of the efforts being made on this continent to solve this or similar problems. To that end there is attached to this report appendix No. 32 prepared by Mr. C. V. McIntire, Consulting Engineer in the field of low temperature carbonization, New York, showing that at the very least well over $8,000,000 has been expended in this general problem. A perusal of this appendix will indicate very clearly two things:—

i) The unanimity of opinion among widely different groups as to the great importance of the low temperature carbonization of our fuels.

ii) The large sums that have been freely spent both by governments and private corporations to solve the problem of the heat treatment of coals in order to produce smokeless fuels, by-products, etc. Compared to the sums spent elsewhere both by governments and purely commercial companies, the expenditure of the Lignite Utilization Board seems comparatively modest — especially in view of the permanent results and equipment obtained.

Work done for The Lignite Utilization Board by Investigators Elsewhere.

During the progress of the work, an absolutely open mind on processes and devices developed elsewhere, has been maintained, and every competent suggestion for investigation has been welcomed. Samples of raw and carbonized lignite were sent to many private investigators and corporations in England, Canada, and the United States, for testing and experimenting in the departments of carbonizing, briquetting, heat treatment of briquettes, and special by-product researches. Unfortunately the information acquired by the Board as a result of all these researches has not been entirely commensurate with the amount of time and money spent. It is sufficient to note here that the Board has been in consultation and correspondence with the following, and the Secretary desires to take this opportunity of recording the Board's appreciation of the efforts made by each of them to supply information of value:

American Cyanamid, Company,..................New York, N. Y.
Professor Bone,..............................London, Eng.
J. A. Davis, Supt. Alaska Station, Bureau of Mines,..Pittsburgh, Pa.
Fusion Corporation Limited,......................Middlewich, Eng.
International Coal Products Corporation,..........Irvington, N. J.
Dr. Klein, Municipal Laboratories,................New York, N. Y.
Low Temperature Carbonization Limited,..........London, Eng.
Mr. F. E. Lucas, Dominion Iron & Steel Co.,......Sydney, N. S.
Professor Layng, University of Illinois.............Urbana, Ill.
C. Mertz, Esq.,..................................Jamaica, N. Y.
Theodore Nagel, Cyanamid Company,.............New York, N. Y.
Professor Parr, University of Illinois..............Urbana, Ill.
Peatral Syndicate Limited,.......................London, Eng.
Dr. Rouse, (Rouse & Campion)..................London, Eng.
C. H. Smith, Esq., Carbocoal,.....................New York, N. Y.
Professor E. Schoch,.............................Austin, Texas.
Mr. A. L. Stillman, Vice President, General Briquetting, Company,............................New York, N. Y.
Messrs. Wheeler & Woodruff......................New York, N. Y.

Definite Proposals Received.

During the course of the Board's work a few definite and concrete proposals were received from various firms not in reply to request to tender, but entirely on their own initiative. The most important of these was a series of three proposals submitted to the Board in February, 1919, by the Foundation Oven Corporation, New York.

This Company in conjunction with the Mashek Engineering Company, had worked up three definite proposals for the construction of a complete carbonizing and briquetting plant. Each of these involved the taking over of the entire responsibility for the building and construction of the Board's plant in the West. The reasons submitted by this Company in favor of their own proposals were, — firstly, the wide knowledge alleged to be possessed by them of secret processes in Czecko-Slovakia respecting low temperature carbonization of lignites, secondly, — the wide experience of their associate company in briquetting, and thirdly, — the financial resources of their parent organization, the Foundation Company of New York. As the adoption by the Board of any one of their proposals would have involved the handing over to the companies in question practically all the Board's financial resources, the decision that had to be made was very important. Owing to the scope of the proposals and also to the standing of the various companies concerned, each of the three proposals submitted was examined in the greatest detail, and analyzed both from the technical and financial points of view. After very mature consideration the Board felt compelled to reject each of the proposals submitted. It is rather interesting to note that the apparent financial attractiveness of these three schemes was to a great extent dependent on the extraction and sale of a wide variety of by-products. Later on in the development of the Board's work, a newly formed subsidiary of the referred to companies, known as the British Foundation Oven Corporation, presented, in 1920, somewhat similar proposals. By that time, however, the Board was thoroughly committed to its own scheme of development, and furthermore failed to see any striking differences between the proposals submitted in 1920 from those submitted in 1919.

Fusion Process

It has already been noted in this report that the use of a cylindrical rotary retort presented certain attractive features. One of the most promising of these ovens is that developed by the Fusion Corporation — Middlewich, England — which Company controls the Hutchins patents, and has made marked progress in the development of a rotary oven. At a time when the Board was proceeding with its work on the Hood-Odell oven very positive claims were made by the Fusion Company regarding the ability of their retort to handle lignite. Arrangements were made therefore to test out 200 lbs. of Souris lignite, and this amount was shipped to England for test, with the understanding that samples of the residue made at different temperatures of carbonization would be returned to Canada for check analyses by the Board. The reported analytical results from England differed so widely from the analysis made at Bienfait, especially in regard to volatile content in char, that lengthy correspondence was necessary to determine reasons for the discrepancies. These were explained to the partial satisfaction of the Board, and it was decided to send over more raw lignite to be passed through a larger retort of the same type in order to place the facts of the matter beyond dispute. This was done and in the beginning of January, 1924, the lignite arrived at the Fusion Company's plant in England. It has not yet been possible therefore to get final results.

In connection with this matter, the Fusion Company submitted very courteously an estimate of the financial aspects of their installation, upon which, however, the Board is not prepared to comment until the technical features in regard to treatment of lignite are determined beyond peradventure. It is, however, necessary to record the thanks of the Board to the Fusion Corporation and also to Mr. C. J. Goodwin, Consulting Engineer, London, England, for much assistance.

Coalite. — Low Temperature Carbonization Limited.

In addition to the efforts made to explore the suitability of the Fusion Retort for low grade lignites, arrangements for somewhat similar tests were also made with the Low Temperature Carbonization Limited, London, England, which controls the process known as "Coalite". On the occasion of Stansfield's visit to London, 1920, some slight investigation was made by him of the process; but the development at that date did not indicate that it was either suitable or economical for treating a non-caking low grade fuel. Subsequent to 1920 large advances have been made in this process, and the Low Temperature Carbonization Limited, at the close of 1923, kindly agreed to make tests for us. With this understanding 200 lbs. of raw lignite were shipped to them in December, 1923. It is, of course, not yet possible to record any results.

Methods Used to Keep Governments and Members of the Lignite Utilization Board in touch with work.

It was felt to be highly desirable that during the progress of the undertaking every effort should be made to keep both the Western members of the Board, and the related governments, in closest touch with the work. In addition there were a certain number of ministers, government officials, and scientific men who should be kept informed of the progress of affairs. The methods adopted were:—

To keep the members of the Board in touch with the developments, weekly reports known as Executive Circulars, were sent out by the Montreal Office to each of the two Western members. These circulars gave in complete detail a resumé on the work conducted during the preceding week, and by their perusal the Western members were able to be in touch with the general progress of the Board's affairs. To date 214 of these Executive Circulars have been issued.

In order to keep the governments in touch a series of "Progress Reports" has been issued from the Montreal Office. These Progress Reports were at first forwarded at monthly intervals to the interested governments and officials, and later on were forwarded at slightly longer intervals. In other words, for the years 1918 and 1919 the Progress Reports were issued at approximately monthly intervals, but as construction work and trials were undertaken the reports were not issued until a sufficient amount of time had elapsed to enable the Board to make and record a definite amount of progress in the interval under review. From October 1st, 1918 to date, 28 of these Progress Reports have been issued and forwarded to each of the following:—

The Right Hon. W. L. MacKenzie King, Prime Minister of Canada, Ottawa.

The Hon. John Bracken, Premier of the Province of Manitoba, Winnipeg.

The Hon. Chas. Dunning, Premier of the Province of Saskatchewan, Regina.
The Hon. Martin Burrell, Parliamentary Librarian, Ottawa.
The Hon. A. B. Hudson, of Hudson, Ormond, Spice and Symington, Winnipeg.
The Hon. J. A. Sheppard, Moose Jaw.
J. M. Leamy, Esq., Winnipeg.
J. McLeish, Esq., Director, Mines Branch, Department of Mines, Ottawa.
P. A. McDonald, Esq., Public Utilities, Commissioner, Winnipeg.
Dr. Chas. Camsell, Deputy Minister, Department of Mines, Ottawa.
J. B. Stevenson, Esq., Assistant to the Auditor General, Ottawa.
Edgar Stansfield, Esq., Edmonton.
F. J. Horning, Esq., Chief, Internal Trade Division, Dominion Bureau of Statistics, Ottawa.
The Hon. W. R. Motherwell, Minister of Agriculture, Ottawa.
The Hon. Chas. Stewart, Minister of Mines, Ottawa.
The Chairman, The Research Council, Ottawa.
Dr. D. B. Dowling, Geological Survey, Ottawa.
O. R. Gould, Esq., M. P., Assiniboia.
The Hon. Jas. G. Gardiner, Minister of Labor and Industries, Province of Saskatchewan, Regina.
Thos. M. Molloy, Esq., Commissioner of Labor and Industries, Regina.
I. F. Roche, Esq., Bienfait.

In addition special financial reports were sent at monthly intervals to, the Federal Minister of Mines, the Deputy Minister of Mines, the Auditor General, and later on to the two Provincial Premiers. Also a considerable number of special reports have been prepared on certain specific phases of the work, and submitted directly to the Minister requesting the information.

The following is a list of special reports issued at the request of the Minister named, in addition to regular Progress Reports.

DATE:	TO:	SUBJECT:
March 8, 1919	Hon. Martin Burrell	Conduct of Enterprise
May 25, 1920	Hon. Arthur Meighen	Conduct of Enterprise
Aug. 4, 1920	Hon. Sir James Lougheed	Housing Scheme
Jan. 20, 1922	Minister of Mines	Financial Situation
Feb. 22, 1922	Hon. Charles Stewart	Financial Support
Dec. 10, 1922	Hon. John Bracken	Accomplishments, History, Objective, Finance.
July 27, 1923	Hon. Charles Stewart	Special report and recommendations treating solely of the Hood-Odel Oven and future policy based on result of work to date.
July 27, 1923	Hon. John Bracken	
July 27, 1923	Hon. Chas. Dunning	
Sept. 14, 1923	Hon. Chas. Stewart	Finance and future operations.

Very little attempt has been made to keep up any publicity in the daily press, but every request from scientific societies, and educational institutions for papers or addresses, has been met by some member of the Board or its staff.

Data Sheets.

As the investigation work proceeded it was felt by the officers of the Board that some permanent and convenient method should be adopted of recording in a useable form the scientific data gained. To that end, 'Data Sheets' were adopted. These sheets were small tracings of standard size on which were recorded in as brief a form as possible the salient features of any particular bit of investigation or research. The size adopted was 7″ x 4″ in order that the resulting blueprints might be bound conveniently in a standard folder. Appendix No. 43 gives a list of the titles of the Data Sheets issued.

High Temperature Metals.

With a view to exploring the possibility of adopting some of the modern high temperature metals either as a floor material for some subsequent development of the Stansfield carbonizer, or as a portion of high duty rotary cylindrical carbonizers, a very brief investigation was made into the high temperature metal field as at June, 1923. The results of this are recorded in tabular form in appendix No. 33.

Staff.

When the work was started in 1918, a secretary, an engineer, and a chemical engineer were immediately engaged. Since that date the technical staff has been added to from time to time, and certain resignations have occurred.

The following is a complete list of the engineers who have occupied responsible positions in the service of the Board. They are listed in the order in which they joined the staff, with date of joining in first column, while the second date, (if any) indicates when they resigned from the Board's service. In the 4th column appears the title held at present or at time of resignation.

	DATE	DATE	TITLE
Lesslie R. Thomson	Oct. 1st/18	—	Secretary
R. DeL French	Oct. 1st/18	Sept. 30/21	Engineer
Edgar Stansfield	Oct. 1st/18	Jan. 31/21	Chemical Engineer
Hammond Johnson	Feb. 11/19	Apr. 30/22	Assistant Engineer
I. F. Roche	Oct. 11/19	—	Resident Manager, Bienfait.
R. A. Strong	Oct. 21/19	—	Chemical Engineer
W. G. Heptinstall	Oct. 4/20	—	Mechanical Superintendent.

A memo of the professional records of all these members of the staff appears in appendix 34.

The Board wishes to take this opportunity of expressing a word of very sincere thanks to each of the above mentioned engineers. Especially is a word of thanks and appreciation appropriate to the cases of Messrs. Roche and Strong who have had a particularly heavy load of vexatious responsibility at the plant during the past two years. The assured technical results now achieved, both positive and negative, have been due, in no small measure to the painstaking and indefatigable zeal of these two engineers.

FINAL SUMMARY

The foregoing somewhat extensive report of the activities of the Lignite Utilization Board can be now concluded by a tabulated summary of results. This digest is submitted in order to present in as condensed a form as possible, the results achieved by the Board during more than 5 years of work.

i) Immediately upon its inception in 1918, the Board started a complete investigation of all existing methods of carbonizing and briquetting of lignite with the discovery that *no* commercial processes had been developed.

ii) This discovery necessitated the embarking upon an extensive fundamental research into the chemistry and physics of lignite carbonization with a view of developing the basic information that would enable the Board to develop a process. This work was done with the active co-operation of the Department of Mines, Ottawa. The information thus gained is available permanently.

iii) As the work developed, semi-commercial carbonizing and briquetting plants were erected in Ottawa. The operation of these plants yielded information of considerable value, also available permanently.

iv) A very thorough test has been given to a special type of lignite carbonizer, and it has been proven non-commercial. Therefore one important ghost has been laid.

v) The Board has erected a large plant of a solid permanent character at Bienfait, and for the operation thereof, has provided housing, water supply, power, chemical control laboratories, and complete mechanical equipment.

vi) The Board has aided materially in the development of a shaft oven carbonizer designed by the combined efforts of Messrs. O. P. Hood and W. W. Odell of the American Bureau of Mines, and of Dean Babcock of the University of North Dakota. This advance has been made possible by the very courteous co-operation extended by each of these three. During this work the American Bureau acted as consulting engineers to the Board.

vii) The Board has solved the technical problems of briquetting lignite char. All known binders were experimented with in Ottawa, and the most economic selected for commercial development at Bienfait. In addition the Board has demonstrated under instructions from the three supporting governments, that the special char from the Hood-Odell oven presents no peculiar difficulties in briquetting, for 150 tons of this char, produced at Bienfait, were briquetted at Hebron successfully, through the co-operation of Dean Babcock — the University of North Dakota.

viii) From the foregoing it is obvious that a *complete process* of making carbonized lignite briquettes has been demonstrated absolutely successfully with full scale equipment. Thus the first half of the original objective laid upon the Board has been attained.

All of the foregoing is very respectfully submitted.

(*Signed*) LESSLIE R. THOMSON,
Secretary.

MONTREAL, *Jan. 25th, 1924.*

Glossary of Terms as Used in this Report

AIR DUCTS............Rectangular cast iron perforated ducts for conveying and distributing air in Hood-Odell carbonizer.

BINDER................Material used for cementing particles of char together in order to form them into a briquette.

BAFFLES...............Metal shapes used for diverting and controlling flow of coal mass in carbonizers.

CARBONIZING..........Process of heating coal (usually in space from which air is excluded) in order to drive off moisture and gas, with consequent concentration of fixed carbon and ash.

CARBONIZER...........The apparatus used in a carbonizing process.

CHAR..................Product of carbonizers, i.e. lignite from which moisture and most of gas has been driven off.

COOLER................That portion of carbonizer used for cooling the char before discharging.

CARBOFRAX............Trade term for carborundum product used as floor material in Stansfield carbonizer.

COOLING TABLE.........Metal conveyor used for cooling briquettes in transit from press to storage.

DRIED LIGNITE.........Lignite as discharged from dryers, usually containing from 5 to 7% moisture.

DISCHARGE MECHANISM.That portion of retort which mechanically controls the rate of discharge of the char.

DISTILLATION..........The process of driving off oils from the tar with the consequent production of pitch.

EMULSION..............An extraordinarily intimate mixture of water and tar.

FINES..................Broken and disintegrated small pieces of coal. As used in this report, term usually refers to material that would pass through ⅛″ mesh.

FLUXER................A machine used for mixing binder and char in the briquetting process. It is usually vertical, with a vertical revolving shaft carrying blades moving in horizontal planes.

GAS OFFTAKE..........Pipe used for extracting gas from carbonizer. The gas offtake discharges into a gas main.

MIXER.................Machine used for mixing binder and char in the briquetting process. It is usually horizontal with a horizontal revolving shaft carrying blades moving in vertical planes.

MIX...................Term used to describe mixture of coal and binder during processing.

MIXING RATIO..........Quantity of binder added to 100 parts by weight of coal or char.

MASTICATOR............A term used by the General Briquetting Company, New York, to cover a special type of machine used for mixing binder and coal in a briquetting process, by passing the mix under heavy wheels rolling on a horizontal pan. Sometimes referred to as Chilean Mill or Edge Runner.

METAL CURTAIN........Steel plate over pipe used in taking off gas in Hood-Odell carbonizer.

OVEN..................Synonymous with carbonizer.

PRESS.................Machine used for pressing "mix" into briquettes.

PERCENT BINDER.......Quantity of binder in 100 parts of final product—briquettes.

PITCH..................Product of distillation of tar.

RESIDUE...............Used in this report synonymously with char, e.g. lignite residue.

REGULATOR............. Apparatus used for controlling gas pressures within carbonizer, or gas mains.
RAW LIGNITE........... Lignite as mined, usually carrying 35% of moisture.
RUN-OF-MINE........... Lignite as mined, previous to sizing.
RETORT................. Synonymous with carbonizer.
SLACK................... Term used for small sizes of coal usually below 1½". See also "fines".
SCREEN ANALYSIS....... Percentage of various screen sizes in any given quantity of coal.
TAR STILL.............. Apparatus used for the distillation of tar.
TAR..................... A viscous brown liquid recovered from the coal in the carbonizing process.
VOLATILE MATTER...... Term used to designate the general gas constitutents of any coal, which are driven off when heated

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APPENDIX 1.

Certified copy of a Report of the Committee of the Privy Council, approved by His Excellency the Governor General on the 20th March, 1918. (P. C. 643)

The Committee of the Privy Council have had before them a report, dated 22nd February, 1918, from the Honourable Martin Burrell for the Vice-Chairman, Reconstruction and Development Committee, on behalf of the Reconstruction and Development Committee, stating that the Reconstruction and Development Committee has had under consideration the subject of the fuel supply in Western Canada and that as the result of such consideration, they find:

That the fuel resources of the Dominion of Canada are second only to those of the United States, the greatest coal country in the world:

That, heretofore, large quantities of anthracite coal, approximating 400,000 tons per year have been imported into Western Canada from the United States, the delivery of which is, however, hampered, at present, by over-taxed transportation facilities:

That it is desirable to guard against the possibility of a fuel shortage, through the further development of our domestic fuel supplies, anthracite coal imported into Western Canada from the United States being, in any case, high in price:

That there are large deposits of lignite underlying various districts of the Provinces of Saskatchewan and Alberta, some of which, in the raw state, can only be utilized when freshly mined, and are, moreover, unsuited in such state to household use:

That by carbonizing this lignite, a coke or charcoal is obtained which briquettes readily and, without consideration of the by-products such as oil, pitch, ammonium sulphate, gas, etc., the result is to turn two tons of inferior fuel into one ton of briquettes approximating, in heating value, anthracite coal with practically the same heating value in the domestic furnace as the two tons from which it was made:

That, although the art of producing carbonized briquettes has passed the laboratory stage, the producer must yet face the difficulty inherent in commercial production and it is desirable that the solution of these difficulties should be undertaken as a public utility in order that the processes involved may be made generally available for the widest possible use:

That it is estimated that an investment of four hundred thousand dollars will be required to provide for the capital charges and for the cost of administration and operation during a sufficient period to establish a commercial process:

That it is understood that the Provincial Governments of Manitoba and Saskatchewan would be prepared to favourably consider a proposal whereby each of them would contribute an amount of one hundred thousand dollars towards this enterprise provided the Dominion of Canada, would, on its part, contribute two hundred thousand dollars; authority for the direction and management of the undertaking to be vested in a Commission to be created.

That it is desirable that an experimental plant should be established for the above mentioned purpose, capable of producing thirty thousand tons of briquettes per year, and that the most advantageous site would be in the Souris District of Saskatchewan on account of the present development of lignite deposits in that district and the readily available market for briquetted fuel in nearby parts:

And whereas the Honourary Council for Scientific and Industrial Research has advised as above, and the Reconstruction and Development Committee, upon full consideration reports in favour of Government action on these lines:

The Committee therefore recommend that an agreement be prepared by the Minister of Mines for giving effect to the foregoing undertaking with the Provincial Governments referred to, setting forth the terms and conditions as to the construction, control and maintenance of the proposed plant, the measure of liability of the three governments respectively concerned, the ultimate disposition of the plant, and any other necessary provisions that in the premises may appear expedient and necessary; such agreement to be subject to the approval of His Excellency, the Governor in Council:

The Committee concur in the foregoing recommendation and submit the same for approval.

(*Signed*) RODOLPHE BOUDREAU,
Clerk of the Privy Council.

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APPENDIX 2.

Agreement made between:

HIS MAJESTY'S GOVERNMENT OF THE DOMINION OF CANADA represented by the Honourable Martin Burrell, His Majesty's Secretary of State of Canada,

HIS MAJESTY'S GOVERNMENT OF THE PROVINCE OF MANITOBA represented by the Honourable Thomas Herman Johnson, Acting Premier of the Province of Manitoba,

and

HIS MAJESTY'S GOVERNMENT OF THE PROVINCE OF SASKATCHEWAN represented by the Honourable William Ferdinand Alphonse Turgeon, Attorney General of Saskatchewan.

(1) WHEREAS a large amount of the coal required for manufacturing and domestic purposes is now imported from foreign countries, and whereas it is becoming increasingly difficult to obtain such coal and the cost thereof is rapidly increasing; (2) and whereas there are large deposits of lignite in the Provinces of Saskatchewan and Alberta and it is desirable that this lignite, some of which can only be utilized in the raw state when freshly mined and is unsuited in such state for household use, should be utilized; and (3) whereas, by carbonizing this lignite, coke or charcoal can be obtained, which briquettes readily and becomes suitable for domestic and manufacturing purposes as well as producing by-products such as oil, pitch, ammonium sulphate and gas; and (4) whereas such treatment of lignite has not yet *been demonstrated for commercial purposes* in Canada, and (5) whereas the said Governments have agreed to supply four hundred thousand dollars for establishing the business as a *commercial industry*, the work in connection with the same to be under control and management of a Board of three members:

Now, this Agreement Witnesseth that the Government of Canada and the Governments of Manitoba and Saskatchewan contract and agree each with the other as follows:—

1. That the Government of the Dominion of Canada will contribute and pay an amount not exceeding two hundred thousand dollars, and the Governments of the Province of Manitoba and Saskatchewan will contribute an amount not exceeding one hundred thousand dollars each, for the purpose of establishing an experimental plant capable of producing thirty thousand tons of briquettes from lignite in each year, and for such investigating and experimental work, whether before or after the establishment of the said plant, as the Board may deem necessary or advisable.
2. That the money required for the undertaking shall be paid by the said Governments from time to time upon the joint requisition of the Board hereinafter mentioned, the Government of Canada paying one-half the amount asked for in each requisition and each of the other Governments one-quarter.
3. That such plant shall be situated in the Souris District in the Province of Saskatchewan.
4. That the building of the said plant and the purchasing of machinery and all property real or personal required for the work and the control and management of the same and of any business connected with or arising out of the undertaking shall be made by and be under the control and management of a Board to consist of three honorary members to be appointed by the Government of Canada, one of whom shall be appointed by the Government of Canada to be Chairman of the said Board, the said Board to be called the "Lignite Utilization Board".
5. That the members of the said Board shall receive no remuneration for their services, but each member shall be entitled to be paid his travelling expenses and also his living expenses when absent from home on the business of the Board.
6. That if any vacancy occurs in such Board the vacant position shall be filled by the Government of Canada.
7. That two members of the Board shall constitute a quorum for the purpose of doing business, and, in cases of difference, the opinion of the majority shall prevail.
8. That the said Board shall from time to time make such reports containing such information and details as any of the said Governments may require.
9. That the expenditure of the said Board shall be subject to the audit of any person designated by the Government of Canada.
10. That all property, whether real or personal, purchased or otherwise acquired for the purposes of the Board and all processes discoveries and improvements which may result from the operation of the Undertaking shall be held in trust for the said Governments, and, upon the completion of the undertaking may be disposed of as may hereafter be agreed upon by the said Governments. If the said property or any of it is sold upon the termination of the undertaking the proceeds shall be devided in the proportion in which each Government has contributed to the undertaking.

In Witness Whereof this Agreement has been executed by said Honourable Martin Burrell, the said Honourable Thomas Herman Johnson, and the said Honourable William Ferdinand Alphonse Turgeon on the Twentieth day of July, in the year One thousand nine hundred and eighteen.

WITNESS:—

(*Sgd.*) WILLIAM IDE. (*Sgd.*) MARTIN BURRELL.
As to the signature of Hon. Martin Burrell

(*Sgd.*) CHARLES SMITH (*Sgd.*) THOS. H. JOHNSON.
As to the signature of Hon. Thos. H. Johnson

(*Sgd.*) CHAS A. DUNNING (*Sgd.*) W. F. A. TURGEON.
As to the signature of Hon. W. F. A. TURGEON.

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APPENDIX 3.

Certified copy of a Report of the Committee of the Privy Council, approved by His Excellency the Governor General on the 22nd August, 1918, (P.C.2064)

The Committee of the Privy Council have had before them a Report, dated 21st August, 1918, from the Minister of Mines, representing that by an Order in Council (P. C. 643), dated 20th March, 1918, the Minister of Mines was authorized to enter into an agreement with the Governments of Saskatchewan and Manitoba concerning the utilization of our lignite coal resources.

The Minister observes that on the 20th day of July, 1918, an agreement was entered into and duly executed and that the said agreement provided for the establishment of a "Lignite Utilization Board" to be constituted of three members to be appointed by the Dominion Government: that such members should receive no remuneration for their services, but each member should be entitled to be paid his travelling expenses and also his living expenses when absent from home on the business of the Board.

The Minister, therefore, recommends that the following gentlemen be appointed on the said Board, namely:—

R. A. Ross, Esq., Montreal P. Q.;
J. M. Leamy, Esq., Winnipeg, Man.;
J. A. Sheppard, Esq., Moose Jaw, Sask., and that Mr. R. A. Ross be chairman of the Board.

The Committee concur in the foregoing recommendation, and submit the same for approval.

Clerk of the Privy Council.

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APPENDIX No. 4

Extract from letter of A. Chase Casgrain, Esq., K.C., to Mr. R. A. Ross.

September 17, 1918.

I consider that the Order in Council of the 22nd of August, 1918, which constitutes a board and appoints the members thereof creates a corporate body known as the Lignite Utilization Board and such board will, in my opinion, without any further incorporation, be considered as a legal entity having the right to acquire moveable and immoveable assets and incur liabilities within the limits of the powers given to it by the contract above referred to of the 20th of July, 1918.

The members of the Board will incur no personal liabilities for the obligations assumed by the Board as long as in assuming the same they do not exceed the powers directly or indirectly conferred upon them by such agreement.

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APPENDIX No. 5

Suggested Lines for Agreement Between the Mines Branch of the Department of Mines and the Lignite Utilization Board.

MONTREAL, *January 18th, 1919.*

(1) E. Stansfield to make Ottawa his headquarters at present, carrying out there his duties as Chief Engineering Chemist to the Mines Branch; that is, supervising the regular work of the laboratory as well as special work for the L.U.B., work on oil shales, etc.

(2) R. E. Gilmore to continue his work on lignite under direction of E. S.; other extra and temporary assistants to be supplied as required by the L.U.B.

(3) Routine analyses, etc., to be carried out by the regular members of the staff as in the past.

(4) The work on lignite to be carried forward as rapidly as possible, and in such order as will best expedite the work of the L.U.B. Ultimate publication of the methods employed and results obtained to be made as a bulletin of the Mines Branch.

N.B. Publication as a Mines Branch bulletin of the work up to the present of Stansfield and Gilmore has been approved by the director, but not yet carried out.

(5) The Mines Branch to carry out such required construction, alteration and repair work as it reasonably can with its own staff and in its own workshops. Extensive work which would interfere with the regular work for the different departments to be done in outside workshops at the cost of the L.U.B.

(6) An additional shed to be built to give extra laboratory space for the work on lignite; this laboratory is required to house a mixer, briquetting press, additional carbonizing ovens, etc. This building to be constructed and paid for by the L.U.B. but to become the property of the Mines Branch when no longer required by the L.U.B.

(7) Apparatus purchased or constructed by and for the L.U.B. to remain their property if desired for use elsewhere. Otherwise such apparatus, etc., will be donated to the Mines Branch at the conclusion of the investigation.

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APPENDIX 6

Memorandum of Agreement made this

at

BETWEEN

THE LIGNITE UTILIZATION BOARD, a body created by Order in Council of the Dominion of Canada dated 22nd August 1918, and having its headquarters presently at the City of Montreal.

Party of the First Part
(hereinafter called the Board)

And
an employee of the said Board.

Party of the Second Part
(hereinafter called the Inventor)

Witnesseth:

That whereas the said Board in carrying out the work for which it has been appointed, to wit: the utilization of lignite for fuel and other purposes and the development of processes and the designing and construction of machinery and apparatus for such purposes, has been appointed a Trustee to hold the rights connected with such processes machinery and apparatus and all discoveries and inventions connected therewith, in trust for the Governments of the Dominion of Canada, of the Province of Manitoba and of the Province of Saskatchewan.

And whereas in order to acquire and maintain such rights it is necessary to apply for letters patent of invention on the names of the inventors thereof and to obtain assignments of an interest in the said letters patent by the inventors thereof to the said Board.

Now Therefore it is hereby Agreed

That the said Inventor shall make application in Canada for patents for such inventions as he makes either solely or jointly with others while in the employ of the said Board and subject to the approval and consent and at the entire expense of the said Board, and shall furthermore assign all interest in the patents to be obtained for such inventions to the said Board, such assignments to be filed in the Patent Office with the said applications.

That the amount of remuneration to be paid to such inventor either jointly or severally for any inventions so patented and assigned as above set forth shall be fixed and determined by the said Board, and shall be at least one-half of the profit accruing from any patent so held.

That whenever the said Board declines to approve and consent to an application for a Patent in Canada under the aforesaid conditions, the Board shall thereupon authorize the inventor in writing, to make application in his own name, at his own expense, and for his own interest and benefit.

That in regard to foreign patents the benefit shall accrue to the inventor, under the conditions as follows:

a. In the event of the Board desiring to control a foreign patent the application shall be made at the expense of the Board and the patent shall be assigned when necessary to the Board, the net revenue to be derived therefrom to be paid annually to the inventor.

b. Any other foreign applications can be made by the inventor and at his own expense upon the written authorization of the Board.

All matters of procedure shall be controlled by the Board and the decision of the Board shall be final.

That the consideration binding this agreement shall be the amount of salary or wages paid by the said Board to the Inventor during the term of such employment.

In witness whereof the parties have set their hands and seals at the place and date above given.

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APPENDIX 7.

This Indenture made in quadruplicate this First day of May, A. D. 1920.

BETWEEN:

WESTERN DOMINION COLLIERIES LIMITED, a body incorporated under the Companies' Act of Great Britain and Ireland, and having its principal office at the City of Winnipeg, in the Province of Manitoba, (hereinafter called "the Lessor").

OF THE FIRST PART.

— and —

MANITOBA AND SASKATCHEWAN COAL COMPANY LIMITED, a company incorporated under the Dominion Companies' Act and having its head office in the said City of Winnipeg, (hereinafter called "the Saskatchewan Co mpany").

OF THE SECOND PART.

— and —

THE LIGNITE UTILIZATION BOARD, a body created by the Dominion Government by Order-in-Council, dated 22nd August, 1918, (hereinafter called "the Board")

OF THE THIRD PART,

— and —

THE TRUSTEES CORPORATION LIMITED, (hereinafter called "the Trustees")

OF THE FOURTH PART.

WHEREAS the Lessor is the owner of a certain parcel of land, lying in the Province of Saskatchewan, being part of the north half of Section 3, Township 2, Range 6 West of the Second Meridian, and more fully hereinafter described (hereinafter referred to as the "demised premises").

WHEREAS the Lessor is the owner of the coal under the said demised premises.

WHEREAS the Board desires to have a lease of the surface of the land comprised in said demised premises with a view to establishing and operating thereon a demonstration Lignite Coal Briquetting Plant.

WHEREAS the Saskatchewan Company is the owner of a water supply system consisting of pumps, pumping station, water tank, pipe line and other parts and appurtenances, the said pipe line running from a point on the Souris River in a northerly direction to the coal mine belonging to the said Saskatchewan Company in the vicinity of said demised premises.

WHEREAS the Board desires in order to conduct its operations from 230 to 250 tons per day of raw lignite coal in the form of slack, pea, nut, egg, cobble or run-of-mine.

WHEREAS the Lessor and the Saskatchewan Company are in a position to supply the Board with the greater part of the raw lignite coal which it will require.

WHEREAS the Trustees are the Trustees for the debenture holders of the Lessor under and by virtue of a Trust Deed to secure debentures, which said Trust Deed is dated the 18th day of July, A. D. 1906 and made between Western Dominion Collieries Limited, of one part, and the Trustees Corporation Limited, (formerly and at the time of the Trust Deed called the Trustees, Executors & Securities (Insurance) Corporation Limited), of the other part, and the Trustees have been requested by the Lessor to let on lease to the Board the hereinafter described premises which are specifically mortgaged premises, in accordance with the terms of this lease and agreement and to enter into this lease and agreement as principals as well as consenting parties.

NOW THEREFORE THIS AGREEMENT WITNESSETH that in consideration of the rents, covenants and agreements hereinafter reserved and contained on the part of the Board to be paid, observed and performed, and for and in consideration of the mutual covenants, agreements and undertakings hereinafter set forth and, as regards the Saskatchewan Company for and in consideration of the sum of ONE DOLLAR ($1.00) cash in hand paid to it at the execution of these presents, the parties do hereby covenant and agree each with the other as follows, viz:—

1. The Lessor and the Trustees do hereby demise and lease to the Board that certain parcel of land in the Province of Saskatchewan containing twenty acres English measure more or less lying within the north half of Section 3, Township 2, Range 6, West of the Second Meridian, more particularly described as follows:—A block of land 1320 feet in length by 660 feet in width, comprising a total area of 871,200 square feet, or an area of 20 acres more or less, as shown upon a plan attached hereto, excepting and reserving unto the Lessor all mines and minerals of every description in, upon or under the demised premises, but without power to the Lessor to work such mines or minerals except with the consent in writing of the Board. TO HAVE AND TO HOLD the said demised premises for and during the period of twenty-one years to be computed from the 1st. day of May, of 1920, yielding and paying therefor yearly and every year during the said term hereby granted the sum of Ten Dollars ($10.00) per annum payable in quarterly instalments of $2.50 payable in advance on the First day of February, First of May, First of August and the First of November in each year, the first of such payments to be made on the First day of May, 1920. Provided that the Board shall have the option of renewing this lease for a further period of twenty (20) years from the expiry thereof upon the same terms and conditions as are hereinbefore or hereinafter set forth by giving notice in writing to the Lessor and the Saskatchewan Company of its intention to renew such lease within 6 months before expiry hereof.

2. The Board during the period of the lease covenants with the Lessor to pay the rent hereby reserved and to pay all taxes, rates, duties and assessments whatsoever whether Municipal, Provincial, Dominion or otherwise which shall be assessed upon the demised premises or upon the Lessor on account thereof during the term hereby demised. The Board shall at all times during the term hereby granted, subject to payment of the rent hereby reserved and to the performance and observance by the Board of the covenants, provisions and conditions hereinbefore and hereinafter set forth on its part to be observed and performed, have peaceable possession and enjoyment of the demised premises without any interruption from the Lessor, its successors or assigns or any other person claiming by, from, or under the Lessor, them or any of them.

3. The Board shall be allowed by the Lessor and/or by the Saskatchewan Company such rights of way across the lands of the Lessor (in common with the Lessor and its grantees) and of the Saskatchewan Company (in common with the Saskatchewan Company and its grantees) as may be necessary to the Board's undertaking as described in the preamble hereto, these rights of way to be furnished without charge, but to be laid out as far as possible in a manner not inconvenient to the Lessor and/or the Saskatchewan Company. The Board shall, from time to time, by notice in writing to the Lessor, specify such rights of way as it may desire and in the event of any disagreement as to the location of these rights of way, or as to the necessity thereof, or as to the balance of convenience between the Lessor and the other parties hereto, the matter shall be referred to arbitration as hereinafter provided. The decision in such arbitration shall be final for a period of four years, but shall thereafter be subject to a revision either by agreement of the parties or in the event of a dispute by arbitration as aforesaid.

4. The Board shall have the privilege of terminating this lease upon giving one year's written notice to the Lessor.

5. The Board covenants with the Lessor to erect and establish within one year from date hereof a fully equipped plant for the manufacture of lignite coal briquettes having a capacity of not less than 100 tons daily output and to operate the said plant continuously from the 1st day of April to the 30th day of September in each year of the term hereby granted, subject however, to delays occasioned by stoppage of raw lignite supply or occasioned by strikes, lock-outs, labour troubles of any kind or description, and any normal or special manufacturing or operating difficulties incident to the processes at present contemplated or for any other causes whatsoever beyond the Board's control.

6. The Board shall during the term of this lease or within three months of the expiry thereof either by effluxion of time or otherwise have the right to remove all buildings, plant and other physical assets belonging to the Board upon the demised premises. The Lessor and the Saskatchewan Company shall give the Board all necessary facilities for the removal thereof during said period.

7. This lease may be assigned or sub-let by the Board to any person or body whatsoever, and all the clauses and conditions hereof shall enure to the benefit of or shall bind such assign or sub-lessee.

8. During the term of this agreement or renewal thereof the Board shall have the unqualified right to carry on upon the demised premises any manufacturing business or process connected directly or indirectly with the making of lignite coal briquettes, and to carry on any manufacture or process of treating or handling lignite coal for any purpose whatsoever, and to carry on any experimentation or investigation, the whole as the Board or its assigns or sub-lessees may see fit. During the term of this lease or renewal thereof the Board shall have the right to bring into the demised premises any lignite coal, machinery, or any other commercial commodity whatsoever, subject as hereinafter provided, and shall also, but subject to the provisions of Clause 5 hereof, have the right to remove from the demised premises any buildings, machinery, apparatus, or other device as it may see fit.

9. The Board or its assigns or sub-lessees shall in exercising any of its rights under Clause 8 hereof pay due regard to the rights of the Lessor and the Saskatchewan Company, and will not undertake any act of process endangering the lives of the employees of the Lessor or of the Saskatchewan Com-

pany or endangering the property of the Lessor or of the Saskatchewan Company or of their employees and the Board covenants to indemnify the Lessor and the Saskatchewan Company each respectively for any and all loss occasioned to them or either of them by reason of any breach of this Clause. Provided further that notwithstanding any of the rights, powers or privileges granted by Clauses 8 and 9 hereof unto the Board, the Board covenants that it will at all times hereafter during the currency of this agreement or renewal thereof indemnify and save harmless the Lessor and/or the Saskatchewan Company from and against all liability for all loss, costs, or damages, of whatsoever kind, which by them or either of them may be sustained by reason of the exercise or the attempted exercise of any of the privileges granted by the said Clauses 8 and 9 hereof. And doth further agree to so indemnify the said Lessor and/or the Saskatchewan Company in respect of such loss, costs, or damages, whether the same are occasioned by any negligence on the part of the Board, its servants, employees or agents, or by reason of the failure to exercise reasonable or ordinary care or any care in the conduct, management, or control of any of such matters, and whether or not such loss, costs, or damages should arise from any omission on the part of the said Board, its servants, employees or agents howsoever.

10. The Board shall have the right during the term of this lease to construct or place in operation upon the demised premises any electric power transmission line that it may see fit. If the Board should need any right of way for such transmission line beyond the limits of the property hereby demised and upon or over other property of the Lessor or the Saskatchewan Company, then such rights of way shall be furnished by the Lessor and/or the Saskatchewan Company in the same manner and subject to the same conditions as are provided in paragraph 3 hereof with reference to other rights of way without further cost to the Lessees, provided that the Board will at all times maintain and keep in good repair the said transmission line and equip the same with all proper safeguards and appliances and will at all times indemnify and save harmless the Lessor and/or the Saskatchewan Company from and against any and all damages, costs or liability whatsoever which may arise either directly or indirectly from the construction, maintenance, or operation of such transmission line, and which may result in any damage whatsoever to the property of either of the said Companies or to any of its employees, servants or agents or to any person who may be in, upon or about the premises of either of the said Companies either with or without the leave or license of either of the said Companies and in respect of any animals which may be in or upon or about the premises of either of the said Companies either with or without the leave or license of either of the said Companies, and whether any such injuries or damages are occasioned by the negligence or want of care on the part of the Board its servants, employees or agents or not.

11. Subject to the provisions of Clause 13 hereof and to any rules or regulations or orders of the Board of Railway Commissioners for Canada or any other body having like jurisdiction herein the Lessor and the Saskatchewan Company each agree to give the Board reasonable switching service as and when necessary between the demised premises and the Board's siding on the main line of any or all railways at Bienfait. The said service shall be given in conjunction with the operation of said spur lines by the said Companies in their own business, and they shall not be obliged to make any special trips for the Board's business alone unless to switch a minimum train of four cars at any one time. Neither the Lessor nor the Saskatchewan Company shall be responsible for any demurrage charges on cars in respect of the Board's business, but said charges shall be borne and paid by the Board alone. The Board will pay to the Lessor and/or to the Saskatchewan Company for such service a switching rate of $4.00 for each and every loaded car when moved by the Lessor or the Saskatchewan Company from the demised premises to the Board's siding at Bienfait and will also pay for switching service from the Board's siding at Bienfait direct to the demised premises the sum of $4.00 per loaded car. If the present switching charge as established by the Board of Railway Commissioners for the Lessor's mine to Bienfait, now the sum of $3.00 per car is raised or lowered above or under $3.00, the aforesaid switching rate to the Board of $4.00 per car shall be raised or lowered in the same proportion. The Board shall also pay for all extra switching in the Board's yards on the demised premises at the rate then prevailing charged by the Canadian Pacific Railway Company for like services, and in the event of dispute such sum as shall be determined by arbitration hereunder.

12. It is further expressly agreed that the Lessor and/or the Saskatchewan Company will supply free of charge to the Board reasonable switching services for empty cars one way in either direction between the Board's siding at Bienfait and the demised premises but the same empty cars switched both ways shall be paid for by the Board at the rate of $4.00 per car provided that if such empty cars are switched one way by one Company and the other way by the other Company. parties hereto, then such switching charge of $4.00 shall be equally divided between and payable to the two Companies.

13. The Lessor and/or the Saskatchewan Company shall be excused from the performance of their respective obligations under Clauses 11, 12, 14 and 16 hereof on account of inability to perform the same from any cause or causes beyond their control including (but without limiting the said generality) breakdowns of machinery or plant, strikes, lock-outs, labour troubles of any kind or description, interruption or suspension of transportation facilities over their respective spur lines caused by weather conditions.

13 (A) Provided that the Lessor and/or the Saskatchewan Company shall not be liable on account of any injury or loss that may at any time occur in respect of any of the buildings, erections, materials, or goods, chattels or other property situated upon the demised premises either belonging to or in the custody or safe-keeping of the Board or for any loss or injury to the contents of any car which may have been placed on any siding or track upon any portion of the demised premises at the request of the Board or in fulfilment in whole or any part of any of the obligations under this agreement and whether any such loss or injury may have been caused by the negligence of any of the agents, servants or employees of the Lessor or of the Saskatchewan Company or by reason of any defect in any of the plant or machinery of either of the said Companies and the Board will indemnify the Lessor and/or the Saskatchewan Company from all loss of or injury to any property owned or used by either of the said Companies while the same may be in or upon any portion of the said demised premises, and which may be caused by any act or omission on the part of the Board its agents, employees or servants or by reason of any defect in any of the plant or machinery of the said Board, and provided that neither the Lessor nor the Saskatchewan Company shall be liable for any damage by fire from any engine engaged in switching any cars either to or from any portion of the said demised premises or otherwise being furnished for the purpose of carrying out any of the obligations on the part of the Lessor and/or the Saskatchewan Company hereunder, and all such engines howsoever brought upon the said demised premises shall be brought thereupon at the risk of the Board in respect of

any damage by fire therefrom howsoever arising and whether due to defective construction or otherwise thereof.

14. The Lessor and the Saskatchewan Company each agree to sell and deliver to the Board free on board the Board's siding on the demised premises during the life of this agreement if and when the Board so request a minimum quantity of not less than 900 tons of raw lignite in each week being the output of the present mines of the Lessor and/or the Saskatchewan Company of the size or sizes indicated by specifications to be issued as hereinafter provided, if such size or sizes are available, and if not the balance is to be made up of run-of-mine lignite, the said quantity to be delivered as nearly as possible in equal daily deliveries (Sundays and holidays excepted) but not less than 100 tons as near as may be each on any one day. The Board shall give reasonable notice in advance of its desire for such coal. The price to be paid shall be the price specified in the respective tenders of the Lessor and of the Saskatchewan Company applicable to the half yearly period during which such sales and deliveries are made as provided by Clause 15 hereof. And it is further agreed that if in such tenders no time is specified for payment then payment for deliveries shall be made on the 15th day of each month for the preceding months deliveries, such payment to be made at par in Winnipeg and in the event of non-payment upon such date, then the Lessor and/or the Saskatchewan Company shall have the right to discontinue further deliveries hereunder until payment for all preceding deliveries has been made in full. The whole object and intent of this Clause and of Clause 15 hereof are to enable the Board to obtain the necessary raw lignite of a satisfactory quality at its plant in proper quantities at the lowest commercial figure.

15. On the First days of April and October of each year the Board shall call for public tenders for the supply of raw lignite coal of the Souris Coal area of the quality covered by specifications to be issued at the time of the said call, to be delivered at the Board's siding at Bienfait. All these tenders shall be sealed and all prices quoted shall be made f. o. b. the Board's siding at Bienfait. The Lessor and the Saskatchewan Company shall make tenders in answer to the said call of the Board.

In the event of the tenders of the Lessor and/or the Saskatchewan Company being accepted, the Board may deduct from the tender price an amount equivalent to \$3.50 per car on all coal delivered to the Board direct from the mine to the demised premises over the spur lines to be built in terms of Clause 18 hereof. This rate of \$3.50 shall be modified pro rata with any change made by the Board of Railway Commissioners in existing \$3.00 switching charge.

16. The Board agrees to furnish sufficient cars (the responsibility of all spotting, switching and placing being upon the Lessor and/or the Saskatchewan Company) at any point between the Board's siding at Bienfait and the demised premises for the transportation by the Lessor and/or the Saskatchewan Company of the coal mentioned in Clauses 14 and 15 hereof, and the failure of the Board to furnish such cars shall, to the extent to which such cars are not furnished, pro rata release the Lessor and/or the Saskatchewan Company from their duty to deliver the quantity of coal called for.

17. The Saskatchewan Company agrees after (first) supplying all the present and future requirements of the Saskatchewan Company, and (second) after supplying all the present and future requirements of the Lessor, to supply to the Board all water necessary for the conduct of its operations up to the normal capacity of the Saskatchewan Company's present pumping plant. But a minimum supply of 100,000 imperial gallons per day is hereby guaranteed. The Saskatchewan Company shall not be responsible for any interruption in the said water supply service arising from any cause beyond its control. The Lessor and the Saskatchewan Company agree to instal meters for the computation of their own consumption of water and the Board will likewise instal a meter or meters for its purposes and each of the parties hereto shall have the right at all reasonable times to inspect the meters of the other parties hereto for the purpose of checking the reading thereof in order that the amount of water used by each party may be periodically known. The price for this service is to be determined by the actual total cost of such service apportioned on a pro rata basis of consumption between the three parties hereto. The actual total cost is to be considered as operating cost, that is to say, wages, plus direct maintenance, (including repairs, replacements, coal, oil, etc.) plus six per cent upon all invested capital for depreciation of such water plant. In consideration of the furnishing of such water at cost the Board undertakes to instal at its own expense all pipes, fittings, connections, meters, etc., necessary to the proper connection of its own piping and water system to the pipe line now owned and operated by the Saskatchewan Company and will at all times maintain and keep the same in good repair and the Lessor will in like manner maintain such pipes, fittings, connections, meters, etc., as are necessary for the proper connection of its water system to the pipe line now operated by the Saskatchewan Company. The Board shall take the water from the Saskatchewan Company's pipe line directly into a reservoir of not less than 170,000 gallons capacity built upon the ground level, the intake pipe thereof shall be connected with the top level of the reservoir but not at a height greater than 25 feet above the ground level. If the Board shall at any time instal a water tower in connection with its waterworks system it covenants that it will transfer the water from its reservoir to such water tower without any connection or interference with the Saskatchewan Company's pipe line. And it is further provided that in the case of any breakdown of any kind upon any portion of the pipe line of the Saskatchewan Company it will proceed with all reasonable despatch to repair the same but the Saskatchewan Company shall not be liable for any damages arising from any such interruption of the said supply arising from any cause within its control until after the expiration of three clear days from the happening of such breakdown, and shall thereafter not be liable for any sum greater than \$50.00 per day from the continuance of such interruption or failure to repair.

18. The Lessor and the Saskatchewan Company each agrees at its own expense to construct and maintain in good repair an extension of its existing spur line from the present terminus thereof to a point on the demised premises as near as possible equidistant, and where the two shall meet and join so that traffic may pass thereupon directly between the parties hereto without difficulty of any kind. One of said extensions to the site of the Board's plant shall be commenced immediately the exact site is settled and completed as soon as reasonably possible, and the other within one year from this date provided the plant referred to in Clause 5 hereof is then completed and ready for operation, and if not, the said second extension is to be immediately constructed after the said plant is constructed and ready for operation as provided in said Clause 5. The Board shall at its own expense construct and maintain in good repair all other necessary sidings, switches and turnouts and yards upon the said demised premises.

19. If at any time during the currency of this agreement or renewal thereof any dispute, difference or question shall arise between the Lessor and/or the Saskatchewan Company on the one hand and the Board or its assigns or sub-lessees on the other, as to any of the matters contained herein then

every such dispute, difference or question shall at the option of either of the parties thereto be referred to one arbitrator if the parties thereto shall agree upon one otherwise the same shall be referred before two arbitrators, one to be appointed by the Lessor and/or the Saskatchewan Company and the other by the Board and the provisions of Part 1 of the Act of the Legislature of the Province of Manitoba, entitled "The Arbitration Act" (R. S. M. 13 Cap. 9) and any amendments thereof shall be deemed to be incorporated herein, and shall be applicable to any arbitration under the terms of this provision.

20. It is hereby expressly declared and agreed between the Lessor and the Board that if the rent hereby reserved or any part thereof shall be unpaid for 30 days after any of the days on which the same ought to have been paid although no formal demand shall have been made therefor or in case of a breach or non-performance of any of such covenants, conditions or agreements hereinbefore contained on the part of the Board then and in any of such cases the Lessor shall notify the Board in writing that it is in default. If after 30 days from the date of service of such notice the Board has failed to pay the amount of rent due or remedy such default, then it shall be lawful for the Lessor at any time thereafter into and upon the said demised premises or any part thereof in the name of the whole to re-enter and the same to have again, repossess and enjoy as its former estate, anything to the contrary herein contained notwithstanding. And provided that the said Lessor shall in the event of service of such notice at the same time serve a copy thereof upon the Saskatchewan Company for its information and in the event of default continuing on the part of the Board the Saskatchewan Company shall likewise have power to enter upon any portion of the said demised premises for the purpose of removing therefrom that portion of the spur line constructed by it together with any other property of the said Company then in, upon or about the said demised premises.

21. The Trustees covenant and agree with the Board that they have done and performed all things necessary and proper under their Trust Deed for the purpose of entering into this binding lease.

22. All questions or controversies as to the rights and liabilities of the parties hereunder shall be decided and determined under the Laws for the time being of the Province of Manitoba and in the event of any litigation being instituted or arising in respect of any of the matters herein contained then the same shall be instituted, brought, heard and disposed of by the Courts of Manitoba. Provided, however, that if in respect of any such question or controversy relief is sought either by way of injunction, specific performance, attachment, or other extraordinary remedy in respect of which the Courts of the Province of Saskatchewan could alone grant relief, then such suit or action may be instituted within the Province of Saskatchewan.

23. Should any of the parties hereto make default in the observance and performance of the various covenants, conditions and provisions to be by them observed or performed respectively, the other parties or either of them may by notice in writing to the party in default cancel this agreement as follows:—During a period of 30 days from service of such notification, the party in default shall have the right to remedy the default. In the event of the default not being remedied, then this agreement shall cease and determine.

24. It is agreed between the parties that each of them will not hire any employee of either of the other parties without such party's consent, and will not hire any ex-employee of either of the other parties until after the expiry of one month from the date when such ex-employee has ceased to be in such employment without the consent of the party in whose service such ex-employee has been previously engaged; and it is further agreed that all of the parties hereto will as far as possible maintain similar rates of remuneration and conditions of service to their several employees engaged in service of a similar class or description, and that they will co-operate with each other in order to avoid disturbing labour conditions in connection with their respective businesses.

25. Wherever the words Lessor, the Saskatchewan Company, the Board and the Trustees are used, they shall include the successors and assigns of each.

In Witness Whereof the parties hereto have hereunto affixed their corporate seals attested by the hands of their proper officers in that behalf.

Witness as to signatures,

T. J. STEWART.

LIGNITE UTILIZATION BOARD OF CANADA

R. A. ROSS,
Chairman.

LESSLIE R. THOMSON,
Secretary.

MANITOBA & SASKATCHEWAN COAL CO. LIMITED

ROBT. WATSON,
President.

J. C. THOMSON,
Sec.-Treas.

The Common Seal of
THE TRUSTEES CORPORATION, LIMITED
was affixed hereto in the presence of

W. S. POOLE,
Director.

BERNARD HEYBURN,
Assistant-Secretary.

WESTERN DOMINION COLLIERIES LIMITED

HUGH SUTHERLAND,
Chairman.

C. G. ASHWIN,
Asst.-Secretary.

HENRY ALFRED WOODBRIDGE, of the City of London, Notary Public, duly admitted and sworn practising in the said City **Do** hereby Certify and Attest

THAT on the day of the date hereof the Comr_on Seal of THE TRUSTEES CORPORATION LIMITED was affixed at foot of the hereunto annexed Agreement in pursuance of a Resolution of the Board of Directors of the said Company in my presence and in that of WILLIAM SANDFORD POOLE, one of the Directors of the said Company, and BERNARD HEYBURN, the Assistant Secretary thereof, who signed in my presence at foot of the said Agreement as witnessing the affixing of the said Seal.

Whereof an Act being required, I, the said Notary have granted these presents under my Notarial Firm and Seal to serve and avail when and where need may require.

Done and **Passed** in London, the eleventh day of August, in the year of our Lord One thousand nine hundred and twenty-two.

(*Signed*) H. A. WOODBRIDGE,
Not. Pub.

—§—

APPENDIX No. 8

Memorandum of Agreement entered into at the City of Montreal, this 30th day of April in the year of Our Lord, One thousand nine hundred and twenty;

BETWEEN

SMITH BROS. & WILSON, LIMITED, a body politic and corporate, duly incorporated, and having its Head Office and principal place of business in the City of Regina, (hereinafter styled "the Contractor"),
Party of the First Part,

AND

THE LIGNITE UTILIZATION BOARD, a body created by Order-in-Council of the Dominion Government dated August 22nd, 1918, (hereinafter styled "the Board"),
Party of the Second Part,

WITNESSETH:

That for and in consideration of the covenants, undertakings and agreements hereinafter expressed or implied, the parties have contracted and agreed together as follows:—

1. SCOPE OF WORK

The Contractor agrees to do, in accordance with the plans and specifications hereto annexed, which plans, numbered and described as follows:—

	DWG.	SHEETS
a, — Track Hopper and Crusher House	C 14	1– 3 incl.
b, — Raw Lignite Bins	C 3	1– 3 "
c, — Dryer Building	C 9	1– 5 "
d, — Carbonizer Building	C 10	1–10 "
e, — Briquette Building	C 12	1– 5 "
f, — Binder Unloading Shed	C 17	1– 1 "
g, — Briquette Bin	C 2	1– 6 "
h, — Power House	C 6	1– 6 "
j, — Coal Shed	C 8	1– 2 "
k, — Office and Laboratory Building	C 5	1– 8 "
l, — Covered Suction Reservoir	C 4	1– 3 "

and which specifications are signed for identification by the parties concurrently herewith, and in accordance with the Bill of Quantities hereinafter set forth subject to the conditions of the clause hereafter agreed to under the heading of "Bill of Quantities", the work described as follows:—

(*a*) The supply of material for and construction of an office and laboratory building, approximately 29 feet by 50 feet, brick veneer.

(*b*) The supply of material for and construction of a car house, 16 feet by 44 feet, wood frame construction.

(*c*) The supply of material for and construction of crusher building 15 feet by 20 feet frame.

(*d*) The supply of material for and construction of two raw lignite bins, 40 feet high by 25 feet in diameter, reinforced concrete.

(*e*) The supply of material for and construction of a dryer building, 84 feet by 40 feet, structural steel, brick curtain wall.

(*f*) The supply of material for and construction of a carbonizer building, 84 feet by 55 feet, structural steel, brick curtain wall.

(*g*) The supply of material for and construction of a briquette building, 55 feet by 42 feet, structural steel, brick curtain wall.

(*h*) The supply of material for and construction of a briquette bin, 80 feet by 16 feet, frame.

(*i*) The supply of material for and construction of a power house, 100 feet by 48 feet, brick bearing walls and wood roof.

(*j*) The supply of material for and construction of a coal shed, 15 feet by 42 feet, reinforced concrete.

(*k*) The supply of material for and construction of a binder unloading shed, 16 feet by 50 feet, frame.

(*l*) The construction of the foundations for, and the erection of a steel tower and water tank to be supplied by the Board.

(*m*) Together with such alterations of the work or of any of the foregoing items, and together with any extras thereto that may from time to time be ordered in writing by the Board under the terms of this contract.

The foregoing shall be referred to in general as the work or works unless the context shall necessitate another interpretation.

BILL OF QUANTITIES

The quantities of material in the respective works above listed are to the best of the Board's knowledge as follows:—

	ITEM	QUANTITY
1.	Excavation	4,700 cu. yds.
2.	Backfill	3,100 cu. yds.
3.	Concrete, 1–2–4	250 cu. yds.
4.	Concrete, 1–2½–5	840 cu. yds.
5.	Concrete, 1–3–6	700 cu. yds.
6.	Reinforcing steel	48,000 lbs.
7.	Brick	380,000
8.	Structural steel	lbs.
9.	Lumber	122,000 ft. B.M.
10.	Shingles	9,000
11.	Corrugated Steel	23,000 sq. ft.
12.	Tar and gravel roofing	95 squares
13.	Lathing and plastering	1,050 sq. yds.
14.	Composition floors	65 sq. yds.
15.	Windows	4,600 sq. ft.
16.	Doors	1,700 sq. ft.
17.	Painting and tinting, not including structural steel	9,100 sq. yds.
18.	Finishing concrete floors	1,800 sq. yds.
19.	Trim and mill work	Lump sum
20.	Hardware	Lump sum
21.	Electric lighting	Lump sum
22.	Heating	Lump sum
23.	Plumbing	Lump sum
24.	Sheet metal work	Lump sum

These quantities have been calculated by the Board from the drawings, specifications and plans hereinafter mentioned, and while every effort has been made to have those quantities as nearly correct as may be, the Board does not guarantee their accuracy but sets them forth purely for the convenience and assistance of the Contractor.

2. PAYMENT TO CONTRACTOR

For and in consideration of the faithful performance of the work in full accordance with the plans and specifications and the terms of this contract, express or implied, the Board agrees to pay to the Contractor the actual cost of the work, as hereinafter determined, together with a fee being the sum of 20% of the final estimated cost of the work as determined hereafter less the sum of 10% of the actual cost of the work, the whole in accordance with the following provisions:—

(*a*) The Contractor submits the following as his estimated tender cost of the work, which cost is made up from the Bill of Quantities above set forth by the application of the unit costs and the lump sum costs set forth hereunder:—

	ITEM	QUANTITY	UNIT COST	TOTAL COST
1.	Excavation	4,700 cu. yds.	$ 2.50	$11,750.00
2.	Backfill	3,100 cu. yds.	1.00	3,100.00
3.	Concrete, 1–2–4	250 cu. yds.	11.50	2,875.00
4.	Concrete, 1–2½–5	840 cu. yds.	11.10	9,324.00
5.	Concrete, 1–3–6	700 cu. yds.	10.50	7,350.00
6.	Reinforcing steel	48,000 lbs.	.07	3,360.00
7.	Brick	380,000	38.00	14,440.00
8.	Structural steel	lbs.		48,839.00
9.	Lumber	122,000 ft. B.M.	80,00	9,760.00
10.	Shingles	9,000	12.50	112.50
11.	Corrugated steel	23,000 sq. ft.	.37	8,510.00
12.	Tar and gravel roofing	95 squares	15.00	1,425.00
13.	Lathing and plastering	1,050 sq. yds.	1.10	1,155.00
14.	Composition floors	65 sq. yds.	3.75	243.75
15.	Windows	4,600 sq. ft.	1.50	6,900.00
16.	Doors	1,700 sq. ft.	1.25	2,125.00
17.	Painting and tinting, not including structural steel	9,100 sq. yds.	.50	4,550.00
18.	Finishing concrete floors	1,800 sq. yds.	1.08	1,944.00
19.	Trim and mill work	Lump sum		1,775.00
20.	Hardware	Lump sum		1,730.00
21.	Electric lighting	Lump sum		2,243.00
22.	Heating	Lump sum		3,136.00
23.	Plumbing	Lump sum		2,914.00
24.	Sheet metal work	Lump sum		682.00
				$150,243.25

The foregoing unit costs are subject to variation according as there may be any increase or decrease in freight rates from the rates in effect on the date of the signing of this agreement; such variations shall be effective when determined in writing by the parties hereto.

(*b*) Upon the termination of the work, the final estimated cost to be used as a basis for the determination of the contractor's fee shall be made up as follows, to wit: — the actual quantities entering into the work and as set forth in clause 2 (a) hereof shall be taken and to them shall be applied the same unit costs as have been used in computing the estimated tender cost referred to above.

(c) For the purposes of explaining the working out of the foregoing arrangement, the parties set forth the following example: — Assuming that the original Bill of Quantities comprises the following.

QUANTITY	UNIT PRICE DETERMINED BY CONTRACTOR	ESTIMATED TENDER COST
10,000 cu. yds. of concrete............	$10.	$100,000.
200,000 feet board measure lumber.......	$35 per M.	7,000.
100,000 lbs. steel......................	8c. erected	8,000.
		$115,000.
Plumbing lump sum price...............		15,000.
TOTAL.......................................		$130,000.

This figure, $130,000 becomes the *estimated tender cost of the work.*

It may be found, however, during the progress of the work, that owing to inability exactly to determine quantities and owing to alterations and extras, the following may become the actual Bill of Quantities:

QUANTITY	UNIT PRICE DETERMINED BY CONTRACTOR	FINAL ESTIMATED COST
12,000 cu. yds. of concrete............	$10.	$120,000.
150,000 feet board measure lumber.......	$35 per M.	5,250.
90,000 lbs. steel......................	8c. erected	7,200.
		$132,450.
Plumbing lump sum price...............		15,000.
TOTAL.......................................		$147,450.

This figure of $147,450 is to be termed *the final estimated cost of the work.*

Owing, however, to the Contractor's superior skill and ability in constructing this work or in purchasing his materials it is found upon the completion of the contract that the actual cost as hereinafter set forth has only amounted to $120,000. Under such circumstances the payment to the Contractor shall be $120,000. (actual cost of work), plus his fee being 20% of $147,450. (final estimated cost), less 10% of $120,000 (actual cost of work). The total payment to the Contractor, therefore, is $137,490. of which $17,490 is his fee. This is irrespective of any bonuses which the Contractpr may earn under clause 7 of this contract.

3. ACTUAL COST OF WORK

The actual cost above referred to in the phrase "Actual Cost of the Work" shall mean the following:

(a) All money and salaries in Canadian funds paid for labour and assistance directly and solely engaged on this work as follows:—

Unskilled labour, masons, bricklayers, plumbers, plasterers, painters, roofers, concrete workers, riggers, engineers and other workers of a similar class, and horses, teams and teamsters together with the direct foremen of any or all of the foregoing.

(b) The salaries in Canadian funds of those men in the organization of the Contractor who are employed exclusively on this work in superintendence, timekeeping, bookkeeping, clerical work, draughtsmanship and storekeeping, and only during such time as they are so employed; it being expressly understood that the number of such men and the amounts of their salaries shall be subject to the approval of the Board.

(c) The costs of all material purchased expressly for this work. These costs shall be deemed to be in the funds of the country of origin. The Contractor hereby undertakes to exercise every precaution and due diligence to obtain the best possible prices for such material, and the Board reserves the right to require, at their own option by giving written notice of such intention to the Contractor, that the Contractor shall have all tenders submitted to him for supply of such material submitted to and opened by the Board or their representatives for the Board's approval before the award of tender by the Contractor.

(d) The value in Canadian funds of any material supplied exclusively and expressly for this work by the Contractor from his own stores. The value of such material shall be determined as provided by clause 8 of this contract.

(e) A service charge in Canadian funds to cover use and depreciation of all equipment supplied by the contractor for the proper performance of the work, such as derricks, lidgerwoods, hoists, engines, concrete mixers, jacks, etc., etc. The Contractor agrees to submit to the Board from time to time a list of every piece of such equipment, brought on the job. Such list shall show the value, date of arrival, condition, date of termination of service, condition and any other pertinent details regarding each piece of such apparatus. The above mentioned service charge for use and depreciation of such apparatus shall be determined at the rate of 15% per annum for each and every piece of such apparatus used.

(f) The cost or value in Canadian funds of such small tools and equipment as are supplied expressly and solely for this work, and which by their nature are liable to be completely used up or worn out on the work. Such items would include picks, shovels, manilla rope, wire rope, steel brooms, bristle brushes, hose, oil skins, rubber boots, together with such other items of a like character as may be necessary for the prosecution of the work in a workmanlike manner. Orders for such equipment must be approved by the Board if the Contractor desire their cost to be included in the work. All such material shall become the exclusive property of the Board.

(g) The cost in Canadian funds of all supplies incident to the carrying on of the work such as coal, oil, waste, gasoline, paper, stationery, linen, feed, hay, grain, taxes, premiums for workmen's compensation insurance, and items of a like character.

(h) The freight charges in Canadian funds on the movement of Contractor's equipment as follows:—

(a) From the Contractor's yard to the site of the Board's plant, or an equivalent amount in money to be applied on shipment from any other place.

(b) From site of Board's plant to Contractor's yards or an equivalent amount in money to be applied on shipment of plant to any other place.

(*i*) The travelling expenses of workmen and officials of the Contractor's organization as follows:—

(*a*) Travelling expenses of workmen from source of labour supply to site of Board's plant.

(*b*) Travelling expenses of workmen from the site of the Board's plant to their original point of embarkation for the purpose of the work. Provided, however, that no such transportation be paid if the workmen be dismissed for cause or leave of his own accord within two months of arrival unless he be honourably discharged.

(*c*) Travelling expenses of higher officials from the Contractor's organization, only, however, when consultations with such officials are requested by the Board.

No charge for workmen's travelling expenses may be presented to the Board unless such movement of men has received the approval of the Board.

(*j*) The cost in Canadian funds of supply and erection of huts, shacks, temporary construction office, bunk houses, etc., which the Contractor may find necessary to erect to accommodate the staff, Such construction must have the approval of the Board, and such buildings shall become the property of the Board.

(*k*) The cost in Canadian funds of any labour or material necessary to instal a temporary water supply for the Contractor.

(*l*) The freight charges and duty, if any, on material purchased and shipped expressly for this work, when such material has been acquired in conformity with the foregoing clauses.

(*m*) The cost in Canadian funds of workmen's compensation insurance.

(*n*) The cost in Canadian funds of tests as provided for in clause 17 of this contract.

(*o*) The cost in Canadian funds of any fire insurance; it being understood that this clause in no way affects the liabilities of the parties as expressed elsewhere in this agreement.

The cost of the work shall not include the cost of spare parts, or any alterations or repairs in either time or material to Contractor's plant or machinery, or the expense of the supply and maintenance by the Contractor of his equipment and plant, save as provided by Clause 3, paragraph (*e*) of this contract.

Beyond the foregoing nothing further shall be considered as cost in the meaning of this contract unless the parties vary this agreement by a new agreement in writing upon the matter.

4. TERMS OF PAYMENT

The Board hereby agrees that the payments to or on behalf of the Contractor shall be made as follows:—

(*a*) The Contractor shall submit to the Board on or about the 16th of each month from the inception to the completion of this contract all invoices for supply of material or labour with proper corroboratory vouchers, and the Board shall pay such invoices directly, and shall charge such payments to the Contractor's account. This clause is deemed to include those cases where the Contractor has acted in the capacity of a vendor to the Board.

(*b*) The Contractor shall submit to the Board monthly receipted payrolls for the various classes of labour involved. These payrolls shall have been paid at such times as are customary for the respective classes of labour, and in submitting these payrolls the Contractor shall also submit all necessary vouchers as may be required by the Board. The Board shall then pay to the Contractor the total amounts of such payrolls.

(*c*) The Board shall make settlement with the Contractor at monthly periods as may be mutually agreed upon, for plant rental and depreciation, fixed at the rate and in the manner above set forth.

(*d*) The Board shall pay to the Contractor the amounts expended by him for freight or travelling expenses as described above. These payments shall be made from time to time as may be mutually convenient.

(*e*) At the close of the work the Board shall pay to the Contractor as his fee to include profit 20% of the final estimated cost as herein submitted less 10% of the actual cost of the work as herein described.

5. BOND

The Contractor shall submit a bond for the faithful performance of this work from a surety Company authorized to transact business in the Dominion of Canada to the amount of 50% of this work in favour of the Lignite Utilization Board. This bond shall remain in force until the termination and formal acceptance of the work.

If the Contractor prefers he may substitute for the bond a certified cheque in a chartered bank of the Dominion of Canada or a National Bank of the United States for the sum of 10% of the amount of this work. Said cheque to be held by the Lignite Utilization Board until termination and formal acceptance of the work.

6. TIME

The Contractor agrees to commence the work within ten days from the date of this agreement and shall so prosecute the work that it shall be ready for occupancy on the 30th July, in so far as regards the office and laboratory building and the boiler and power houses; and the whole work shall be entirely completed on or before the 6th day of September, 1920. The maintenance of a proper rate of execution of this agreement is of the very essence of the agreement and the Contractor agrees to do all things and to take all necessary precautions to insure that such a rate of progress shall be maintained in order that the work may be entirely finished within the time specified.

7. DAMAGES

The Contractor agrees to pay to the Board as liquidated damages the sum of $100.00 per day for each and every day that he delays the completion of the entire work to be done under this contract. The Board shall have the right to deduct such liquidated damages from any moneys due or which may become due to the Contractor under this contract, and shall also have the right to collect from the Contractor or his surety any excess of such liquidated damages over and above the money that would be otherwise due the Contractor. Notwithstanding anything elsewhere stipulated these damages do not disallow

the Contractor from payment of his fee less any deductions to be made therefrom in accordance with the terms of this contract. In the event of the Contractor being able to completely terminate the work before the date agreed upon, he shall be entitled to a straight bonus of Five hundred dollars ($500.00) for each and every full week gained.

8. SOURCE OF MATERIAL

The Contractor undertakes to supply all material necessary for the completion of the work, either from his own stores or by purchase, and the said material shall conform strictly to the specifications. In the event of material being supplied from the stores of the Contractor, then shall such material be valued at current market rates, which rates shall be subject to the written approval of the Board. If material is purchased in the open market, then the Board reserves to itself the right, if desired, of having all tenders to the Contractor for supply of said material forwarded to the Board and opened in the Board's office in Montreal, Winnipeg or Regina, for purposes of examination and approval of the Contractor's award.

9. MAINTENANCE OF EQUIPMENT

It is expressly agreed that the Contractor shall supply and maintain at his own expense all his equipment in first class condition subject to the provisions of clause 3, paragraph (*e*) of this contract.

10. OVERSIGHT OF WORK

(*a*) The Contractor agrees to maintain at all times during the progress of the work at the site a competent superintendent and staff. Any formal notice that the Board may serve upon such superintendent shall be deemed to be served upon the Contractor.

(*b*) From time to time upon the demand of the Board the Contractor shall supply free of charge the service of higher executive officers for the purpose of advice, consultation or inspection.

(*c*) The Contractor agrees to superintend and direct all work and labour to be performed in the construction of the work.

11. GENERAL COVENANTS BY THE CONTRACTOR

(*a*) The Contractor acknowledges that he has read and understands this contract, all the clauses of which will be strictly enforced; that he has examined the site to his satisfaction and is satisfied therewith.

(*b*) The Contractor further agrees that should any conflict of interpretation arise as between his offer or other papers issued by him, or which he is contemplating or may prepare on the one hand, and any papers issued by the Board, the interpretation of the Board's papers shall be held to govern.

(*c*) The Contractor agrees that during the progress of the work he will comply in every way with any Governmental or municipal regulations or with the requirements of Departments of Labour of the Province of Saskatchewan and of the Dominion Government with regard to wages, conditions of work and so forth.

(*d*) The Contractor agrees to assume the risk of any infringement that may be made on any patents or patent devices used or utilized by him in the construction of the work.

(*e*) The Contractor undertakes that he will not, without the written consent of the Board, assign this agreement or sub-let any portion thereof.

(*f*) The Contractor shall erect buildings in the order indicated by the Board.

(*g*) During the progress of the work there will be other contractors engaged on or about the buildings at present described. The Contractor under this contract hereby agrees to afford every facility to every other such Contractor or sub-contractor in the prosecution of their respective contracts.

(*h*) The Contractor shall not suffer any workmen's lien or other encumbrance of registration to be made upon the work or upon the property or premises of the Board.

(*i*) The Contractor shall insure against all claims under workmen's compensation acts applicable to his employees.

(*j*) The Contractor shall insure against all risk by fire to the work.

(*k*) The Contractor shall be responsible for all structural and decorative damage to property and for injury caused by the works or workmen to persons, animals or things; and shall hold the employer harmless in respect thereof.

12. PLANS AND DRAWINGS

All plans and drawings whether general or detail prepared by the Contractor, shall be subject to the approval of the Board, before any work covered by such plans and drawings is begun; and the said approval shall be signified in writing by the words "Approved for construction". Any plans and drawings so marked shall not be departed from without the written authority of the Board. The Contractor agrees to keep complete sets of all plans revised to date at the site. The Contractor further agrees to supply to the Board at the termination of the work three complete sets of all drawings, plans or sketches issued during the progress of the work, if such sets of drawings, etc., are desired by the Board. It is expressly understood that the responsibility lies with the Contractor to submit all drawings for the approval of the Board.

Approval of the Contractor's plans, drawings or sketches by the Board shall not relieve the Contractor from mistakes therein or from his responsibility for the design, construction or performance of the work or for any costs, damage or expenses which may be sustained or incurred by either party by reason of such mistake.

All drawings, plans or sketches, and especially those necessary to permit the completion of buildings and structures for the Contractor's work or to allow of other contracts being let must be furnished with the greatest promptness by the Contractor to the end that the Board's work as a whole may be carried on in the most rapid and continuous way.

13. RISK

All losses and damages arising either from the nature of the work or due to the action of the elements, unforeseen circumstances or the King's enemies, shall be borne by the Contractor and shall not be chargeable to the actual cost of this work: and the work shall be at the risk of the Contractor until final completion thereof and acceptance by the Board.

14. SPECIAL PLANS

The Board hereby agrees to furnish general plans and designs showing lines, grades, limits of property, relation to water supply, etc., to the Contractor within twenty days from the date of this contract.

15. ALTERATIONS AND ADDITIONS

During the course of the work it may be necessary to make certain additions or alterations from what is now shown on the drawings, plans and specifications. It is expressly agreed that these changes and alterations shall be made only upon written authorization from the Board.

16. EXTRAS

Extra work shall be interpreted to be work, not contemplated, indicated, described or implied in the original drawings, plans or specifications hereto attached. Such extra work shall, however, be undertaken by the Contractor upon the written authorization of the Board as if it had been shown beforehand upon the drawings, and shall thereupon become subject to the provisions of this work. The material entering into such extras shall be subsequently added to the listed quantities of this work.

17. DISCREPANCIES, INSPECTION, ETC.

(*a*) The whole intent and purpose of this agreement are to have a group of industrial buildings erected for the Board's purposes as quickly as possible and at a reasonable cost, and to establish during their construction a basis of mutual interest between the Board and the Contractor. To that end the Board has prepared drawings, plans, specifications and agreements and so forth. If, in the preparation of same there have been omissions, discrepancies or other unintentional mistakes, the Contractor hereby agrees to interpret such specifications, drawings, plans, etc., with a view to accepting their real intention expressed or implied. It is to be distinctly understood that this agreement has been drawn with the express purpose of creating a mutual interest between the Board and the Contractor to do the work herein set forth as thoroughly and as economically as their respective efforts may enable.

(*b*) During the progress of the work the final decision on all matters of this contract shall rest with the Board or the Board's representatives. This clause, however, shall not be deemed to exclude the Contractor from the right to final arbitration. The intention of this clause is to state that on matters of routine, matters of engineering or constructional skill, or on any matters of engineering or constructional interpretation of the agreement, the decision of the Board shall be final.

(*c*) The Board reserves the right to make inspection of and to test the work under this contract at such time and in such manner as the Board may see fit. The Contractor hereby agrees to afford the Board every assistance and facility for the conduct of such inspection. Upon demand of the Board the Contractor shall have tests made of any or all material entering into the work. The Board shall have the right to require that such tests shall be a prerequisite to acceptance. Such tests shall be conducted at the discretion and under the direction of the Board.

If during the progress of the work, the Board shall decide after any inspection or test made by it, or by the Contractor, that the Contractor has executed any unsound or imperfect work, or has supplied any materials, apparatus or plant of inferior quality to those specified, the Contractor shall at his own expense within twenty-four hours of his receiving the Board's written notice to this effect proceed to alter, reconstruct or remove such apparatus or plant or to supply new materials up to the requirements of the specifications.

(*d*) The Board reserves the right upon giving written notice to the Contractor to reject any certain portions of the work which in the judgment of the Board are not in quality of workmanship or material up to the requirements of these specifications. Such written notice shall state clearly the reason for the rejection of such work. The cost of such rejected work which cost shall be agreed upon by the parties on a basis of net labour plus overhead of all kinds pro rata shall not be chargeable to the Board's account, and it shall be deducted from the actual cost of work as herein described.

(*e*) All computation of costs, quantities, time, material, if such computations are to be used and have authority for record, shall be subject to the written approval of the Board at the option of the Board.

18 HINDRANCES AND DELAYS

If, in the judgment of the Contractor, the Board is delaying the work by failure to give decisions or for any other reason whatever then the Contractor shall notify the Board of such hindrances and delays, and if admitted by the Board, the time of such delays shall be added to the date for the termination of the contract. In like manner should the Contractor be delayed in performance by any cause absolutely beyond his control, the time of such delay shall be added to the delay for the execution of the contract.

19. DEFAULT

Any undue delay, any violation of the terms of this agreement or the abandonment of this contract shall be deemed to terminate it. Such termination shall come into effect within ten days from date of notice by the Board that such termination has been decided upon. In the event of termination of the contract in such manner, then the Contractor shall have no recourse or claim of any kind upon the Board for his fee and in addition the Board shall have the right to collect from the Contractor or his surety the difference between the sum of moneys already paid plus the amount necessary to complete the contract on the one hand, and the final estimated cost on the other hand.

The Contractor shall also be deemed to be in default if he should, in the opinion of the Board, fail to show good faith in performing any stipulation or requirement of the contract, or to obey promptly any written order of the Board, or if he should die, go into liquidation, become insolvent or bankrupt, commit any act of bankruptcy, compound or offer to compound with his creditors, have a receivership order made against him, carry on business under an inspector or receiver for the benefit of his creditors, or to permit any execution to be levied on his property, or if he should assign his contract or subject any part of the work without the consent in writing of the Board.

20. ACCEPTANCE

Upon the completion of the work the Contractor shall notify the Board thereof, and the Board shall then have the right to inspect and verify the work. The work shall not be deemed to have been accepted by the Board until it shall have expressed its acceptance in writing after final inspection. The Contractor's fee shall become due and exigible within thirty days after such acceptance.

21. DELIVERY OF PREMISES

The Contractor shall return all drawings, plans, copies of specifications and so forth, that may be in his possession and shall take all steps to evacuate the premises forthwith. The Contractor, after thoroughly cleaning up all parts of the work and the surrounding grounds from the rubbish and dirt caused by or accumulated in the performance of the contract and removing all sheds and workmen's quarters so as to leave the site in a neat and presentable condition, shall deliver the buildings and premises to the Board.

22. NOTICES

Any notices intended for the Contractor shall be sufficiently authenticated if signed by the Board or its accredited representative, and any notice intended for the Board shall be sufficiently authenticated if signed by the Contractor. Any such notice shall be deemed to be duly served on the person intended if delivered to him in person or to his representative on the work, or left at his place of business or if deposited postage prepaid in the Post Office, duly addressed to him at such said place of business. Service of any such notice shall be conclusively presumed to have been made at the time when it should have been delivered in the ordinary course of post. The address of the parties is understood to be that stated in this agreement.

23. ARBITRATION

In the event of arbitration being necessary in connection with any dispute or disagreement between the Contractor and the Board, each party shall appoint one representative and these two shall choose a third. In the event of their not being able to agree, then the Chief Justice of the Province of Saskatchewan shall be asked to nominate the third member of the Board of Arbitrators. However appointed, the third apointee shall be the Chairman of the Board of Arbitrators. The Arbitrators shall bear in mind the purposes of this agreement and its effective execution as a guiding principle. The cost of any arbitration proceedings shall be apportioned by the Board of Arbitrators.

24. LEGAL PROCEEDINGS

The parties terminate domicile at the City of Montreal, in the Province of Quebec, and all proceedings, claims and actions shall be had, served or made under the jurisdiction of the Courts of the District of Montreal, except in so far as in this contract it may be otherwise provided.

In Testimony Whereof the parties hereto have executed these presents at Montreal, on Friday, this Thirtieth day of April, One thousand nine hundred and twenty.

Signed, Sealed and Delivered by the party of the First Part in the presence of
F. THOMPSON

SMITH BROS & WILSON LTD.
Per D. D. SMITH,
Vice President.

Signed, Sealed and Delivered by the party of the Second Part in the presence of
F. THOMPSON

LIGNITE UTILIZATION BOARD OF CANADA
R. A. ROSS, *Chairman*,
LESSLIE R. THOMSON, *Secretary.*

§

APPENDIX No. 9

MONTREAL, *January 20th, 1922.*

THE HONOURABLE, THE MINISTER OF MINES,
Ottawa, Ont.

Re: Operations of Lignite Utilization Board.

Dear Sir:—

Confirming my promise, I submit herewith a digest of the financial situation of the Lignite Board as at to-day's date, and also a request that further financial assistance be rendered to the Board in order that the project may be brought to a successful conclusion.

For convenience this report is divided into the following heads:—

I Present financial situation.
II Present technical situation.
III Amount of assistance required.

I. PRESENT FINANCIAL SITUATION

In June, 1921, the House of Commons passed a supplementary estimate for the sum of $140,000 to complete the total amount required by the Lignite Utilization Board. This sum was divided as follows:—

a) To provide operating expenses during preliminary period...............	$100,000
b) To provide balance of capital required to complete construction of plant..	40,000
	$140,000

I regret to have to inform you that this amount has been completely expended as follows:—

Operating Expenses	$42,000
Capital Expenditure	94,000

You will observe that the expenses on capital overrun the original estimate by an amount of $55,000. This has been due in the main to an error in estimating the total amount necessary to complete the plant buildings and equipment. While serious, this error is 7.8% of total cost of plant, housing and machinery. Needless to say the Board deeply regrets that this error should have been made.

The further result, however, of this situation is that at present the Board is out of funds and is operating on small cash balances which are really due certain of our creditors. Under such circumstances you can readily appreciate the urgency of the matter in order that the work may not be further delayed.

In closing this part of the report, the following is a brief digest of the Board's expenditures from October 1st, 1918, to December 31st, 1921, a period of three years and three months.

Engineering Administration and Experimental	$ 93,000
Travelling	9,000
Capital (land, buildings, housing, machinery, etc)	703,000
Miscellaneous	6,000
	$811,000

II. Present Technical Situation.

The present situation in regard to the main plant at Bienfait is that each of the following departments has been tested and found satisfactory — power equipment, raw lignite handling machinery, conveying equipment, drying equipment, cooling equipment, binder storage and handling equipment, water system.

The following have been tested and will be satisfactory after very slight alterations — briquetting equipment and briquette storage.

The carbonizers have been tested and found partially satisfactory, that is to say, the mechanical operation has been demonstrated and their principle has proved sound. Certain troubles, however, have developed with the gas pressure control, with leakage, and with floor materials. Enough work has been done to justify the Board in stating that solid confidence exists that when the changes now contemplated are finished the carbonizers will run successfully. These changes include new layout of floor of carbonizer flues, slightly different control of the combustion flues, changes in the layout of the brickwork in order to reduce leakage, and certain changes in the handling of the lignite gases. These last mentioned changes are briefly — the provision of a small gasometer, and more delicate type of pressure regulators.

Until these changes are made the rest of the project must mark time, as carbonizing is the very heart of the matter.

III. Amount of Assistance Required.

Careful estimates have been prepared by the Board as to the cost of the changes contemplated, cost of new material necessary, and attention has also been given to the cost of operating the Board until such time as the receipt of briquette sales will more than pay for the operations conducted. These estimates show a total requirement of *$250,000*.

This amount can be broken up into two divisions, namely, the requirements for immediate expenditurs in order to keep the Board going, liquidate present obligations, and purchase new material for changes already described. This amount equaling *$125,000*. The remaining *$125,000* may be set up as a bank credit against which the Board may draw if and when necessary.

The total amount spent by the Board to date in its undertakings is *$812,000*. This includes plant and houses. The real value of this plant, unless regular operation be established, will just amount to the scrap value of machinery and buildings, which, of course, will be very small. The total amount now asked for is but 30% of the total expenditure, and only 15% of this amount is required in immediate cash.

(*Signed*) R. A. Ross,
Chairman.

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APPENDIX No. 10

Report of February 22nd, 1922 to the Honourable Charles Stewart, Minister of Mines Ottawa, Ont.

Montreal, *February 22nd, 1922*.

The Honourable Charles Stewart,
Minister of Mines,
Ottawa, Ont.

Dear Sir:—

Referring to our interview of January 31st, 1922, and to your request that the Lignite Board take the initiative in obtaining the concurrence of the Provinces of Manitoba and Saskatchewan in extending further financial support in the amount of $250,000 as outlined and requested in our memorandum to you of January 20th, 1922, we beg to report that,—

I The Provinces of Manitoba and Saskatchewan have each agreed to contribute their respective shares of the new amount requested (namely $250,000) provided the Dominion Government also contributes its share on the original basis.The authority for this statement is contained in appendices (A) and (B) to this report.

II In view of the above mentioned action of the Provinces, we would again respectfully urge the Dominion Government to grant the whole of the further amount now required, and thereafter collect the respective amounts from the Provinces.

In support of the foregoing recommendation, and in direct reply to Mr. Camsell's letter of February 3rd, 1922, we beg to submit the following statement of the Lignite project. The various headings are numbered for reference.

A PRESENT SITUATION:

1. Present condition of Bienfait Plant.
2. Technical results so far obtained at Bienfait, especially as to — {a Carbonizing / b Briquetting}
3. Supply of raw materials.
4. Marketing.

B FUTURE PLANS:

5. Completion of changes to carbonizers.
6. Installation of small gasometer and pressure regulators.
7. Trial operations.

C FINANCIAL POSITION:

8. Present situation as to cash resources.
9. Analysis of amount spent.
10. Relation of Provinces.

A — 1 — PRESENT CONDITION OF BIENFAIT PLANT

The present condition of the Bienfait Plant may be stated briefly: The plant is completed and the following parts have been tested and found satisfactory: power equipment, raw lignite handling machinery, conveying equipment, drying equipment, binder storage and handling equipment, water supply and distribution.

The following have been tested and will be satisfactory after very slight alterations: briquetting equipment and briquette storage.

The cooling equipment has not been tested thoroughly owing to the fact that we have not produced more than a couple of tons of briquettes.

The carbonizers have been tested and found partially satisfactory, and their status is discussed more fully in the next paragraph under the head of A2a.

At the close of the trial runs of our carbonizers, about the middle of last December, the plant was shut down almost completely in order to save as much money as possible; and the only work going on at the present moment is the supply of electric light and water between the hours of four p. m. and midnight. These services are maintained with the dual purpose of affording fire protection and supplying water and light to the employees.

The question of our staff at Bienfait is a very critical one. After some years of work the Board has selected gradually a number of men who are accustomed to and had been trained in our special activities, and it would be calamitous indeed if for any reason they were allowed to go. The Board has retained them at the site in the confident belief that the governments would authorize the continuation of the work at the earliest possible moment. If, however, quick action is impossible it will be very difficult to retain any of our men for more than a few days longer.

A — 2 — TECHNICAL RESULTS SO FAR OBTAINED AT BIENFAIT:

The general technical results obtained by the Board since its inception have been submitted to the governments concerned from time to time, by means of Progress Reports Nos. 5 to 22 inclusive. It therefore seems unnecessary to repeat this information.

The technical results obtained at Bienfait, are in the main confined to the operation of the carbonizers, and these may be summarized as follows:—

(a)The mechanical operation and the principle of the new carbonizers (on which patents are held by the Lignite Utilization Board in Canada, the United States, Australia, and Italy), have proven entirely satisfactory. Considerable trouble has been experienced, however, with leakage, inclined floor material, and gas pressure control. Very complete test runs were conducted at Bienfait in order to determine the cause of these troubles, and work did not cease until sure knowledge has been obtained as to their causes and remedies. The estimated value of these carbonizers to the industry is enhanced markedly by the fact that the capital cost of construction per ton of estimated output is not much more than half of the corresponding figures(so far as such can be obtained by correspondence) of any other retort of which the Board has knowledge, — even if such retorts could by any stretch of the imagination be felt to be commercially feasible to the carbonization of Canadian lignites. Therefore, the real importance of the results attained to date can hardly be overestimated.

To recapitulate, carbonizing is the very heart and kernel of the problem of producing a lignite briquette for domestic consumption. The Board started operations in 1918, and, published reports to the contrary notwithstanding, the Board discovered that no carbonizers suitable for commercial treatment of Canadian lignites were available. It therefore became necessary to develop one of our own. This was done and two models have been built and operated successfully in Ottawa. It was only after this stage had been reached that the Board ventured to build its large carbonizers at Bienfait. In these large ones the principle has been proved sound, and the capital cost of construction per ton of estimated output is very much lower than any other in the world, with the additional point that not a single one of them would, in the judgment of the Board, carbonize Canadian lignites under commercial conditions. The changes necessary in our apparatus, while expensive, do not vitiate the principle, and the Board is confident that when completed the carbonizers will operate successfully.

(b)The briquetting results obtained to date at Bienfait are not of much value because no doubt exists in the mind of the Board that the problem has already been solved due to the exhaustive briquetting work undertaken at Ottawa through the courtesy of the Mines Branch, Department of Mines. We have produced at Bienfait about two tons of briquettes, but they are far from the standard set by the Board, and were only made to try out machinery.

A — 3 — Supply of Raw Materials:

The two most important raw materials are lignite and binder. The supply of lignite is practically unlimited. The Board is located at the centre of gravity of the Estevan field. In making its lease agreement, the Board included in that document provision for the supply by the two mining companies, parties thereto, of all the lignite necessary to carry on its operations. This obligation is only to be carried out at the desire of the Lignite Board. *In addition* to the two mines thus obligated it will be possible to draw on any of the remaining mines in the district, and commercial market conditions will determine where purchases will be made.

The supply of coal tar pitch is covered by a straight agreement with the Dominion Tar and Chemica Company, Sault Ste. Marie, to furnish coal tar pitch of the required character to the Board in the quantities necessary when operating at full output.

A — 4 — Marketing:

The Board has concluded arrangements with two large distributing companies to market our product when available throughout the two Western provinces. The terms of this arrangement are briefly: The Board allows a straight fee of 25c. per ton handled, and in return the distributors agree to (a) Pay the Board in cash on the 15th of month for all shipments made during preceeding month. All questions of bad debts are therefore on the shoulders of the distributing company. (b) To submit retail selling prices to the Lignite Board for approval. (c) To provide proper distribution throughout various parts of each province.

B — FUTURE PLANS

The below mentioned notes on future plans are made on the assumption of continued financial support.

(5) Completion of Changes on one Row of three Carbonizers.

In order to try out the efficacy of various types of carbonizer floors the Board has decided to furnish one carbonizer with double carbofrax slabs, one carbonizer with carbofrax hollow tile floor, and one carbonizer with fire clay D shaped tiles. The Board has hopes that each of these will operate successfully, and proposes to select the best of the three for the construction of all the remaining carbonizers. The questions of difference of rate of expansion between fire clay and carbofrax, the provision against leakage from the combustion flue into the carbonizer flue, and the prevention of leakage through the combustion flue walls have been carefully examined and thoroughly discussed. The Board feels that the present designs will take care of all the troubles previously encountered.

(6) Installation of Gasometer and Pressure Regulators.

In addition to the changes on the floor of the carbonizers, the Board proposes to install a small gasometer to take care of the fluctuations in quantities of gas discharge, and two pressure regulators of a much more sensitive type than the compensator previously installed. We have been driven to the opinion that our previous estimate on the sensitiveness required in our gas pressure control (namely + or — 1/10″ water) permitted too wide a variation in pressure. It should be noted at this point that in the very nature of the case so far as our problem is concerned it was impossible to demonstrate the best type of gas apparatus by means of models. No gas installation was made at Ottawa, and it was not until our regular gas installation had been completed at Bienfait that we were in a position to find out the relation between the new carbonizers and the gas system.

(7) Trial Operation of Carbonizers.

When the change will have been completed to one row of three carbonizers, trial operations will immediately commence with the idea of obtaining the knowledge necessary to maintain the constant operation of the retorts. At this time also trial operations of all other parts of the plant will be undertaken, in order that each department will be whipped into shape. It is inevitable that all new machinery and apparatus will present the usual number of preliminary troubles, but these must always be faced when placing any new plant into operation.

C — FINANCIAL POSITION

(8) Present Serious Conditions

The Board wishes to reaffirm its previous report of January 20th, 1922, and again call the attention of the government to the fact that we are operating on a very small cash balance, which is really due some of our creditors. It will be impossible to continue this operation for more than a few days longer, and some action must be taken immediately, which the Board urges most respectfully.

(9) Analysis of Expenditure

Engineering & Administration	$ 95,138.45
Travelling	9,753.44
Capital & Preliminary Maintenance	714,418.66
Miscellaneous	11,339.04
	$830,649.59

(10) Relation of Provinces to Financial Situation

As previously mentioned the present request for assistance in the amount of $250,000 was laid before the two Provinces, and each of them has consented to undertake to pay its share of this amount with the understanding of course, that the Dominion Government carry on its share. In view of this decision on the part of the two Provinces, it is evident that the whole matter now rests in the hands of the Dominion Government.

Respectfully submitted,

R. A. Ross,
Chairman.

APPENDIX A OF MAIN APPENDIX No. 10

PROVINCE OF MANITOBA
OFFICE OF THE PREMIER, WINNIPEG.

WINNIPEG, MANITOBA, *Feb. 16th, 1922.*

R. A. Ross, Esq.,
Chairman Lignite Utilization Board,
Montreal, P. Q.

Dear Sir:—

Mr. Thomson, the Secretary of your Board, has within the last few days put the case of your Board for additional financial support of $250,000 before our Government and an informal meeting of the Legislature. I have no intention of trying to conceal our disappointment at the delay as well as the great excess of the original estimate. Confidence in yourself and your judgment has been quite a factor in assisting us in reaching conclusions, Mr. Thomson I may say presented the case very well and frankly answered every question addressed to him.

My supporters in the House will favor the additional vote, and I have the asssurance of two of the other leaders of groups in our House to the same effect. You may therefore feel assured that Manitoba will vote our share of the additional money needed.

I sincerely hope this final effort will crown with success this great experiment in which we have risked so much.

Yours faithfully,
(*Signed*) T. C. NORRIS.

APPENDIX B OF MAIN APPENDIX No. 10

REGINA, SASK., 5.15 p. m. *Feb. 13 1922.*

LESLIE R. THOMSON,
Winnipeg, Man.

Your wire Government here will continue financial support as requested on same basis as heretofore provided Manitoba and Dominion agree provide their share.

(*Signed*) CHAS. A. DUNNING.

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APPENDIX 11

THE AMERICAN CHEMICAL MACHINERY COMPANY
Engineers — Coppersmiths — Machinists

CHESTER, PA. *November 2, 1922.*

LIGNITE UTILIZATION BOARD,
288 St. James St.,
Montreal, Canada.

Attention Mr. L. R. THOMSON, *Sec.*

Dear Sirs:—

Confirming our conversation of this date regarding the blower supplied your Bienfait plant, which has shown under operating conditions to be too small for the work and not in accordance with the specifications mentioned in our estimate for the contract, we are pleased to advise as follows:

1. We accept the responsibility in principle for the defect in the matter.
2. We also agree to accept responsibility for the expenses of the Canadian Blower & Forge Co's representative, amounting to $148.38.
3. We agree to make alterations at our expense to the present blower, installing a new driving engine or turbine to operate at up to 2500 R.P.M. and to replace the present rotor of the blower with a 28″ diameter rotor. For this alteration the Lignite Utilization Board agrees to pay us the sum of $500.00, such payment to be made after the new blower mentioned below is installed.
4. We will at once proceed to obtain a suitable blower of the positive pressure type capable of handling the gas up to the pressure called for in the specifications (one pound), and install same on your foundations with your common labor at our expense for freight, duty and cost.

We trust that this will make the matter satisfactory, and are very sorry to have had such a disconcerting difficulty arise in this otherwise pleasing transaction.

Yours very truly,
AMERICAN CHEMICAL MACHINERY CO.
(*Sgd*) JAS. C. LAWRENCE,
President.

APPENDIX 12

Portion of Minutes of Winnipeg Conference held Jan. 8th, 1923.

WINNIPEG, *January 8th, 1923.*
11.30 a. m.

MORNING SESSION

Memorandum of Conference held in Premier Bracken's office, in the Legislative Building, the following gentlemen being present:

Representing the Federal Government — Dr. Camsell and Mr. Haanel;

Representing the Government of the Province of Saskatchewan — Premier Dunning, Messrs. Cross and Gardiner;

Representing the Government of the Province of Manitoba — Premier Bracken, Messrs. Craig, Clubb and McLean;

Representing the Lignite Utilization Board — Messrs. Ross, Leamy, Thomson and Roche;

Premier Dunning presiding.

As Chairman of the Lignite Utilization Board Mr. Ross made the following statement:

On behalf of the Board, he expressed satisfaction at this meeting being called, as he believed they had arrived at a point where a definite understanding as to the future of the Board was necessary. He thought there were few questions more important to the Dominion at the present time than the question of the fuel supply.

Briefly reviewing the work of the Board, Mr. Ross mentioned that in the first place the Research Council was established in 1916, which conducted an extensive investigation and appointed Committees to deal with various subjects, among those being fuel. Dr. Adams, Dean of McGill University, Dr. McKenzie, President of Dalhousie University, and Mr. Ross were the members of the Committee appointed to go into this question.

In 1917 these gentlemen had reported to the Dominion Government, recommending an appropriation of $400,000 for the purpose of carrying on investigations in Lignites in the North West; this recommendation being accompanied by a technical report as to costs, which estimated that at the rates then prevailing it would be possible to turn out Briquettes for about $7.00 per ton at the plant. This recommendation and estimate had followed a careful study of all available material, which had convinced the Committee that sufficient experiments had been conducted to have brought the matter to a stage where commercial exploitation might be undertaken.

After some delay and after careful consideration, the Federal Government had decided that as much of the benefit of this undertaking would accrue to the Western Provinces they should be asked to share in the expense. Finally Saskatchewan and Manitoba came in, on the basis of the Government of each of those Provinces assuming 25 per cent of the expense incurred by the Dominion, which policy has been continued to date.

The three Governments then established the Lignite Utilization Board, representative of the three Governments. The Research Council had anticipated that the Mines Branch of the Dominion Government would have taken this work over, but the Provinces requested that as they were providing some of the money it should be handled by a Board on which they would be represented.

Mr. Ross reminded the gentleman present that when he was appointed Chairman of the Board he had made two stipulations: 1st, That the funds for the use of the Board must be placed in the Bank to the credit of the Board; and, 2nd, That the Board should not be paid. In this connection he expressed the appreciation of the Board in the confidence which the Governments have placed in them, in the matter of administering the funds, and gave the assurance that they had taken every possible precaution to see that the money was well expended and faithful records kept.

Following the constitution of the Board in October or November, 1918, a programme was mapped out at a meeting similar to this conference.

The Board decided to not accept reports or results of any other organization, but to investigate them personally. This had been proven to be a wise course, as they had found that for their purposes at least they could not accept published statements. This was partly due to the fact that experiments conducted had been purely technical, while the object of the Board was to develop a commercial plant.

The result of investigations and experiments carried on in Ottawa, with the co-operation of the Mines Branch, was that the Board learned how to briquette, learned a good deal about binders, and came to realize that the carbonizing would be the point that would determine their success or failure. This belief was confirmed when the plant was constructed.

Up to that time, carbonizing had not been done commercially by any one, successfully; nor, so far as Mr. Ross knew, had it been done since. As nothing in existence was suitable for their purpose it was necessary to provide a carbonizer of their own, which after some experiment was found to be satisfactory in laboratory form but which gave some further trouble when built in commercial size, of brick and concrete. When these difficulties were overcome, they felt that they were justified in going ahead with the construction of the plant, which was built during the very worst years — 1920 and 1921. It was found to be impossible to get all the material necessary and much of it had to be secured second-hand, but it has proven very satisfactory.

When operation of the plant was begun, further difficulties were encountered, due to increasing the size and number of carbonizers. Since that time experiments have been carried on, and practically all the troubles the Board has met have been in connection with carbonizers.

The layout of the equipment for briquetting had been rather unsatisfactory also, for which the Board acknowledged responsibility; but this can be remedied at a cost of a few hundred dollars, and is not a real difficulty.

The carbonizers were for the purpose of not only producing a char for briquettes but producing by-products — gas, ammonia sulphate, oils, etc. The Board felt it was important to be in a position to effect this saving of by-products.

One of the troubles had been with refractories. Special metals had been investigated, but none had been found which bear the temperature required for carbonizing the ground coal — 1800 to 2000 degrees on one side and 1000 on the other. The heat transmission of fire clay was also too low for this purpose.

They had finally decided on a special product—carbofrax—a carborundum product, manufactured at Niagara Falls, with a heat transmission of almost five times that of fire clay, resembling metal in its transmission power, but supposed to stand a very high temperature.

These, however, had cracked when used. In addition to the ordinary leakage caused by cracks in a retort, these allowed flame to escape from the chamber below, and let gas out and air in. The presence of air in the retort causes the formation of an explosive mixture; on the other hand, the loss of the gas renders the work room uninhabitable.

They had trouble too with the gas off-take. In this connection Mr. Ross pointed out that it had been impossible to experiment with this problem until the commercial plant was operated. The fans had been constructed to work within a sensitiveness of 1/10 of an inch water gauge which they believed would be fine enough, but it had been necessary to reduce this to one millimeter It is necessary to keep the gas, not under pressure, not under suction, but coming off from the material as a curling wisp of smoke, and that balance has to be maintained in the whole system — a very difficult thing to do.

These were the two chief troubles.

Mr. Ross expressed the conviction that the retorts at present in use are not going to be a success commercially, as they are too complicated — the gas off-take regulation has to be too fine, and the chances of leakage are too pronounced.

There has come to the attention of the Board a more recent form of retort, not in existence at the time these were installed, but developed within the last year, in which there is no taking off of gas in the way necessary in the plant at present. One objection to this retort, however, is that it does not conserve the by-products at all, but is simply a process of coking a char, using the gas that comes off in the process for heating. Under this system there would be a large quantity of ash in the product — the 7 or 8 per cent present in good coal having to be doubled through reducing two tons to one, and an additional amount due to the burning of the material. In spite of these objections, Mr. Ross thought the good features of the system warranted investigation, as it would produce a char, with no by-products, and eliminate much of the difficulty experienced at present. The loss of the by-products he thought was not serious, as these newer retorts are simple to make and very cheap.

However, there had been considerable trouble in developing this simple retort, and Mr. Ross was not prepared to recommend it to the Governments unless it were fully investigated first.

Replying to a question from Mr. Dunning, Mr. Ross stated that the plant is not operating at present at its full capacity, but is subject to all sorts of stops; but that they are turning out a small amount of briquettes which are distributed to be tested out.

Mr. Dunning stated that he has used these briquettes in his fireplace and found them entirely satisfactory, so that it was evidently a question of turning them out commercially.

Mr. Ross explained that all the carbonizers are not in use, and those which are operated are not in use continuously. While the coal chars well the briquettes are not always satisfactory and have to be rejected. He thought this could be overcome, but it would require continuous oversight by experts and the cost would be prohibitive.

Mr. Ross urged that whatever decision might be reached as to the best method of continuing this work, the Governments should not consider abandoning it, as it was of great importance, not only to Western Canada but to the East as well as they would be forced to manufacture their domestic fuel in the near future. He referred to the work done by the Board and to the harmonious co-operation between the members, and gave the assurance that the Board would work with anyone or in any way it was decided was best; and urged that the question of the personnel of the Board should not stand in the way of the accomplishment of the work.

He expressed regret at the necessity for indefiniteness in his recommendations, mentioning that the new carbonizer (L.U.B.) difficulties had only been brought to his attention that day and to Mr. Thomson's the previous evening.

The information regarding the Hood-Odell oven had been rather indefinite, as he had understood at first that this was turning out 16 tons of material per day, and later was informed that this [was only 8 tons. For this reason he was not prepared to express any definite opinion as to this retort, although he understood it does away with air and gas leakage and with heat transmission. While it would thus overcome the difficulties at present facing the Board in the operation of the plant, he had no doubt that there would be other difficulties encountered.

Premier Greenfield of Alberta, who was present at the Conference in an unofficial capacity, said he had understood from Mr. Odell and Mr. Hood that this carbonizer did produce 16 tons per day. Dr. Camsell remarked that the figure 16 tons had been mentioned, but he did not know whether it referred to raw coal or to the carbonized material. Premier Greenfield replied that this might explain the difference in the understanding of the report.

Mr. Ross pointed out that laboratory experiments are practically useless from a commercial point of view, as they do not demonstrate cost of production, machinery, etc. Mr. Dunning agreed with this opinion, adding that it was the original intention that this should be demonstrated to be a commercial success, so that financial organizations would take it up and the country benefit by the operation of the system.

In view of the fact that two-thirds of the coal mined in Western Canada is of such a low grade that it is not commercially feasible to ship it, Mr. Ross claimed that it is obvious that some form of manufactured fuel must be used, as was done in Germany before the War. At the request of Mr. Dunning, Mr. Ross explained that the system adopted in Germany could not be introduced in Western Canada on account of the difference in the quality of the coal, the brown coal in Germany containing a binding material not found in Canadian coal, and can be pressed into bricks without carbonizing and without any binder being used. In our coal, as it comes out of the mine there is something like 35 tons of water in every 100 tons of coal, and when this is taken out there is only dust left, which will not stick together, and which is practically worthless in that form.

Premier Dunning reminded Mr. Ross and the members of the Board that about one year ago the Board had requested further financial assistance from the Governments, for the purpose of making certain necessary changes and installing further equipment, largely in connection with carbonizing, he had understood, following which it was understood the project would have been put on a commercial basis. This financial assistance had been furnished, the changes made and equipment installed, and the report now is that it is not a commercial success. He added that the Government of Saskatchewan is not represented at this Conference for the purpose of withdrawing from the movement, but they were looking to the Board to recommend the next step to be taken. He pointed out that it is not always possible to secure from the

Legislature the necessary appropriation for investigations and experiments carried on by Boards and Commissions outside the jurisdiction of the Government, particularly when there is no immediate expectation of financial returns. He assured the Board that he appreciated their position, and realized that in work of this kind scores of failures may precede final success.

Dr. Camsell expressed the same opinion as Premier Dunning, that, as a representative of the Federal Government, he thought the work could not be dropped , but should be carried on to completion.

Premier Bracken stated that the Manitoba representatives, being comparatively unfamiliar with the movement, have a perfectly open mind; that they realized that there is an enormous wealth that can only be utilized in some such way as this, and if there were any hope of accomplishing their aims they were not prepared to withdraw; but he remarked that when this was begun he understood it was estimated that $400,000 would complete the work, then $800,000 was fixed at the outside limit. He added that unless they were convinced that some good would be accomplished by the experiments, Manitoba could not invest any more money in the project.

Mr. Ross pointed out that the Board had requested an allowance of $250,000, one-half of which was to be used for further experiment and construction and the remaining $125,000 for commercial exploitation — sale of the product, etc. The first $125,000 was advanced, of which $30,000 is still in the possession of the Board. At the present time there is no request being made for money, and what future appropriation would be necessary would depend on the policy decided upon at this conference.

While the Board were of the opinion that the best thing to do would be to carry on commercial production as far as is possible under the present system and sell the product, thereby satisfying the public that something was being done, and at the same time carry on experimental work on new retorts. Since talking with Mr. Roche, however, they had come to the conclusion that it would be unwise to continue using the old retorts, when other retorts are reported to be available which show so much promise. This was not an official recommendation of the Board, as there had not been sufficient time to discuss the question since Mr. Ross had talked with Mr. Roche.

Mr. Ross then presented the following alternatives which are open to the Governments:—

First — To shut down the plant and abandon the work. This he thought would be ill advised.

Second — To go ahead with the present carbonizers and get as nearly commercial results as are possible. This he did not approve of, as the production would not be good enough and the public would be led to believe that more was being accomplished than really was.

Third — To turn out as much material as possible under present conditions and at the same time go on with experiments on carbonizers. This would satisfy the public and at the same time make it possible to conduct further experiments. This, however, Mr. Ross did not advise.

Fourth — To announce that they are not satisfied with the carbonizers and have decided to spend no more money on the work until more satisfactory carbonizers are secured when the plant could be operated commercially.

He again pointed out that this summary is given without authority from the Board and is his own personal opinion only.

Replying to a question from Mr. Craig, Mr. Ross stated that the total cost to date is something over $800,000, Mr. Dunning adding that Manitoba and Saskatchewan have each contributed more than $200,000 of this amount. Dr. Camsell pointed out that the Board has $30,000 of this amount which has not been used, in addition to $125,000 which was voted by the Federal Government but which has not been turned over to the Board. Mr. Dunning then stated that the total amount voted by Saskatchewan and paid out was $236,250, and that Manitoba's share would be identical with that.Dr. Camsell said that the Dominion Government has advanced $945,000, of which $915,000 has been expended.

Replying to a further question from Mr. Craig, Mr. Ross stated that it is impossible to quote the cost per ton of producing briquettes, and that the Board has never authorized the publishing of any estimates that have appeared in press reports.

The Research Council estimated the cost at $7.00 per ton, at the plant, but this estimate had been based on 1916 figures, including coal at about $1.00 per ton at the mine head, which has since risen to about twice that figure, and other items have increased proportionately; and the Board has not committed itself to any figure, as until the plant is operated commercially no one can tell what labor, machinery, material, repairs or maintenance costs will be. Later, however, Mr. Ross mentioned that at the time the Research Council made the estimate of $7.00 per ton, anthracite was selling in Regina for about $15.00 per ton — which meant a spread of about $8.00 between the two; today anthracite is selling for about $25.00, and he thought there was no doubt that the spread is as great now as then. He also mentioned that, allowing for depreciation, etc., as had been done originally, and estimating as nearly as possible the probable output of the plant, they considered that the briquettes should sell at $12.25 at the plant, or about $18.00 in Winnipeg. These figures, however, he stated were given reluctantly and could not be relied on as authentic. Mr. Craig added that Alberta coal is selling at from $12.00 to $17.00, according to the grade.

Mr. Dunning mentioned that there is no doubt that the product from the Board's plant is equal to Pennsylvania anthracite, and that the only problem is to produce it on a commercial basis. Mr. Ross claimed that the briquettes Mr. Dunning had used were not as good as the plant can produce. Dr. Camsell claimed that a comparison should not be made between the briquettes and American anthracite, as the latter would not be in competition with Canadian coal much longer; but that the price of Alberta coal would have to be taken into consideration. Mr. Dunning thought if the process of briquetting were successful it would be adopted largely in Alberta also, and that while the price, ton for ton, would be in favor of Alberta coal as compared with briquettes, it probably would not be as regards fuel value, and that also the element of convenience and absence of clinkers would be an advantage in selling briquettes. Mr. Ross was of the opinion that on a heat unit basis it was impossible to institute a comparison between the briquettes and Alberta coal. In connection with the element of competition, Mr. Ross mentioned that the Peat Board had expected to sell peat at about one half the price of anthracite, as it had only about half the heat value, but it had been found easy to sell it in Peterboro at $14.00 per ton when anthracite was selling at about $18.00, as people preferred it on account of the small amount of ash and absence of clinker. He thought the same would apply to briquettes, and that, on a heat unit basis, people would be willing to pay more for this product than for Western coal.

Mr. Dunning mentioned that lignite miners in Southern Saskatchewan feel they are discriminated against in the matter of freight rates, mile for mile, as compared with Alberta miners, and that they feel if this were corrected they could compete successfully with Alberta coal, even with their raw product. He also stated that he understood that Souris lignite, in its raw state is being used in Winnipeg and in Saskatchewan more and more, and that if it were dried, so that it would not be necessary to pay freight on about 30 per cent water, no doubt it would be used more generally. He thought it would not be a bad thing if Alberta mine owners were to turn out briquettes, even in competition with the Souris briquettes.

Dr Camsell replied that the question of competition with Alberta would still be, he thought, an important one as regards the price at which the briquettes can be sold. Mr. Dunning pointed out that several factors enter into the question of competition, mentioning that he had paid $16.00 per ton for semi-anthracite coal from Banff rather than $11.00 for Alberta soft coal, although the additional value in heat units probably was not there. He also thought that the volume of production from the Souris fields would not be sufficient to make it a serious competitor with any other mines, within the next twenty years.

Mr. Gardiner expressed the opinion that if the briquettes were sold at anything less than $5.00 in advance of Alberta coal they would be able to compete successfully.

Replying to a question from Mr. Craig, Mr. Ross said that the heat value of the briquettes is quite equal to anthracite, whereas the estimated cost he had quoted was $5.00 less than anthracite, and he thought that was an outside figure.

Mr. Craig asked why the production of briquettes at the Bienfait plant is not commercially feasible at the present time. Mr. Ross replied that he considered the plant a commercial success, but that there are technical difficulties in the way of production at the present time, which he agreed made production on a commercial basis impossible until those difficulties were overcome. Replying to a further question from Premier Bracken, Mr. Ross stated that his estimated cost of $12.25 at the plant was provisional on the carbonizers being successful.

Mr. Gardiner asked if the adoption of the Hood-Odell Carbonizer would not involve doing away with practically all the equipment in the drying plant. Mr. Ross thought the drying plant would still be necessary, but Dr. Camsell stated that with the Hood-Odell machine it is not necessary to dry the material. In that case, Mr. Ross said all the equipment would be necessary except the present carbonizers and driers; he thought the pulverizers would be retained.

Replying to a question from Premier Dunning, Mr. Ross said that if the Hood-Odell carbonizer proved satisfactory, it would be a much cheaper process of producing char. He also stated that these carbonizers had been developed by the United States Bureau of Mines and therefore had a certain official standing; also, that the patents are open and the Department is willing to co-operate with the Board if they wish to make any experiments with the machine.

Dr. Camsell referred to Mr. Thomson's letter, submitted to himself and to Premier Bracken, outlining certain proposals of the Board for the future. In view of the fact that Mr. Ross had expressed a personal opinion at this meeting which conflicted with those recommendations, he thought the Government representatives would like to have a definite recommendation to take the place of Mr. Thomson's letter. Premier Dunning suggested that the personal opinion expressed by Mr. Ross might be discussed by the Board and an official recommendation brought in. The members of the Board stated that it was not necessary to consider Mr. Ross' statement more fully, as they agreed with his opinion and were quite prepared to have it submitted as an official recommendation.

Dr. Camsell remarked that if the Board recommended that the plant be closed and the investigation proceeded with, he would like their opinion as to how they propose to work, asking if Mr. Hood had not made some proposition as to the use of the carbonizers. Mr. Thomson replied that Mr. Hood had assured them that the Bureau of Mines would be glad to do anything in their power to assist the experiment, and had also referred them to the Dean of the University of North Dakota, who had expressed himself as very willing to have them run through a few tons of the lignite to test it out. Beyond that their inquiries had not gone, and no specific proposition had been made.

It was suggested that the members of the Board should retire, in order to consider further suggestions which might be presented when the conference resumed in the afternoon, and to allow the Government representatives to discuss the question from their point of view.

Mr. Ross readily agreed to this suggestion, but before withdrawing he again assured the meeting that he considered this work too big for any personalities to interfere with its completion, and asked that they feel free to make any arrangement that might be for the best. He mentioned that he is not able to give this work the amount of time he had given it earlier in the programme, when he had spent two or three hours in the office every day, but he thought this was not necessary at present anyway.

Premier Dunning expressed the appreciation of the Governments of the service rendered by Mr. Ross and the members of the Board, and assured them that this apparent criticism of results was not intended as a criticism of the members.

AFTERNOON SESSION

WINNIPEG, *January 8th, 1923. 3.30 p.m.*

Memorandum of Conference, held in Premier Bracken's Office, with representatives of the Federal Government, Saskatchewan Government, Manitoba Government, and of the Lignite Utilization Board present, as noted in the Memorandum of Conference held this date, at 11.30 a.m.

Mr. Ross reported that the conference between the members of the Board had been very brief, and that any statement he might make at this Conference could not be made unreservedly. He again mentioned that Mr. Roche's report in regard to the Board's carbonizer had been made to him only that day, and that therefore the change in the opinion had been rather sudden and the details had not been fully considered. At present the Board is of the opinion that it would be advisable to shut down the plant, and proceed to investigate the Hood-Odell carbonizer, at the same time making inquiries into other systems that may have been developed in the meantime. While the plant was closed, the readjustment of briquetting machinery could be gone into also, the necessity for which the Board frankly admits is their fault. Watchmen would need to be retained and fires kept on in some of the buildings, but not many, and the water could be turned off. It was thought this would cost about $3,500, monthly, or very little more; and the money on hand would cover this cost for about nine months.

As to the method of conducting the investigation into the Hood-Odell carbonizer, Mr. Ross suggested that about 100 tons of coal should be shipped to Grand Forks, where the carbonizer is at present, and run through there, after which it could be briquetted, if that were wished, shipped back to Bienfait, or disposed of in some other way. This he thought would cost about $1,500. This should enable the Board to decide whether this carbonizer was worthy of further experiment, and they might then recommend that one should be built at the plant, probably with certain improvements that would be found to be advisable.

While this was being done, Mr. Ross proposed that they should continue investigations as to further possibilities. He mentioned that they had always considered a rotary machine, but had been unable to secure one that would stand the necessary temperature. Mr. Haanel said that about two years ago he had investigated such a carbonizer then being operated in Crescent, Pa., which he thought had been proven successful, under a temperature of 1200 degrees.

Mr. Ross also thought that the fact that both the present carbonizer and the Hood-Odell depended upon gravity for feed was an objection, and he would like to secure a positive feed.

Dr. Camsell asked if it would not be better to build the carbonizer at the plant and conduct the experiment there. Mr. Ross replied that he did not wish to argue against this suggestion, but he thought having to build it in the open would be an objection, and to overcome that it would be necessary to erect another building. Mr. Haanel thought it could be operated in the open. Mr. Ross was of the opinion that it would be better to experiment with the carbonizer now at Grand Forks before erecting one at the plant, as the Board would then have the advantage of their experience before building one; he thought too that the sale of the material would go a long way toward meeting the expense of this experiment.

Mr. Haanel asked whether, in the event of it being decided to erect the retort at the plant, it would be advisable to have the people who constructed it and worked with it come up and assist in the erection and operation. Mr. Ross replied that he did not think this was necessary, and would involve an expenditure of about $2,000, according to the report of the Bureau of Mines, and he thought it might amount to $3,000 or $4,000. His suggestion would also permit of the experiment being made with less delay.

Reference was made to the possibility of changes being necessary in the retort to adapt it to the Souris coal. Premier Dunning said he believed the coal was identical, but Mr. Ross said he understood that in the experiments conducted at the University of North Dakota the coal used had been picked, while the Board would prefer to use the run-of-mine. It was agreed that the Board should use their own coal for the experiment, whether it were made at Grand Forks or at the plant.

Replying to a question from Dr. Camsell, Mr. Ross said he thought there would be no difficulty in securing permission to make use of the retort, but that it is closed down at the present time.

Dr. Camsell remarked that his Department had confined their inquiries to the Bureau of Mines, who had recommended that an improved retort should be erected at the plant, offering the assistance of one of their engineers; but evidently the Board had secured further information from the University of North Dakota; and he was not in a position to say whether the recommended improvements were of sufficient importance to warrant erecting another retort for the sake of embodying them. Mr. Ross thought there was a possibility that even the suggested improvements might not meet the needs of the Board, in which case they would have to erect another retort after having experimented with the one first erected at the plant.

Mr. Roche stated that estimates he had secured showed that the cost of conducting the experiment at Grand Forks would be about $1,200, while the cost of building a retort at the plant would be about $2,600, in addition to which the element of time should be considered. The Dean of the University of North Dakota had said that they did not feel competent to say what changes should be made in the present retort.

It was agreed that the plant should be closed and that the Board should proceed to investigate the Hood-Odell retort; the representatives of the two Provinces expressing their willingness to leave the decision as to whether these experiments should be conducted at the plant or in North Dakota to the Board and the representatives of the Department of Mines, after they had fully considered the question. Mr. Ross mentioned that the experiment could probably be completed at Grand Forks within a month, whereas considerable delay would result from building a retort at the plant. He gave his assurance, however, that he was perfectly willing to do the work in whatever way was decided to be best.

The Board was authorized to investigate other possibilities, in the meantime, but confining their expenditures to the investigation of the Hood-Odell carbonizer.

Mr. Ross referred to the Morgan producer, which he thought might be satisfactory, mentioning that it is a gas producer, to be used for carbonizing purposes. Mr. Haanel thought the fact that the Hood-Odell carbonizer is a gravity-feed was not an objection to it; stating that he had mentioned this to Mr. Odell in Washington who had said that they had experienced no trouble on this account although they have put through 2,000 tons of residue, as whenever they have an interference in the feed they drop a poker down and it starts off again.

Mr. Roche said he understood from the Dean of the University of North Dakota that when they were operating this retort at Grand Forks the people objected to the gas which escaped. Mr. Haanel replied that this is rectified now, and he thought it would not trouble any one; that he had inquired about this and had been told that there is a certain amount of gas passes through the top which does not burn, but that it is not advisable at this stage to make any attempt to overcome this as it really is not serious. Mr. Ross thought a burner at the top of the stack would overcome this difficulty, as this would turn CO to CO_2.

Replying to a question from Premier Dunning, as to the greatest reduction in staff that it would be possible to effect, after closing the plant, Mr. Ross said that the whole cost for the operations of the Board would be about $3,000 per month, including necessary coal and a few small supplies and the salaries of such of the official staff as would be required. He proposed to retain the services of the technical men, who would be required for experimental work in various places and for re-arrangement of the briquette equipment. Premier Dunning remarked that it had been suggested that for this purpose the services of a briquetting engineer should be secured, which Mr. Ross agreed might be advisable. Premier Dunning, however, stated that it was not considered wise to go on with this work during the experimenting with the carbonizers. Mr. Ross replied that the work in connection with the briquetting equipment, which he had suggested, would not involve any expenditure of money.

In reply to a further question from Premier Dunning, Mr. Thomson said that the Board had engaged a briquetting engineer from New York, to assist with the briquetting. Mr. Ross thought bringing in engineers from the United States was uncomplimentary to the Canadian men, but Premier Dunning pointed out that this kind of work had been done in different parts of the States, and the suggestion is that a man with experience in the work should be secured. Mr. Ross further stated that he was heartily in sympathy with the suggestion that the services of an engineer experienced in this kind of work should be secured, although at the moment he did not know of such a man who was available.

Premier Dunning informed Mr. Ross that the Government representatives were rather concerned about him being located in Montreal, so far from the work. Mr. Ross replied that he would be quite willing to withdraw to allow some one nearer the plant to take over the work, but that it was impossible for him to spend more time on the ground, and he thought it was also unnecessary, mentioning that the men in charge had given very satisfactory service, and full reports were made each day to the members of the Board, who in turn report to the Governments.

Replying to a question from Premier Bracken, Dr. Camsell said that the $125,000 of the last $250,000 voted by the Federal Parliament is still available for the work of the Board, provided it is turned over to the Board before the end of March, after which time it would be necessary to re-vote it. Premier Dunning said the share of that amount which Saskatchewan would need to contribute was not available, unless voted by the next Session of the Legislature; but Mr. McLean explained that this had been voted by the Manitoba Legislature and was on deposit at the present time, the investment having been capitalized. Manitoba's

total vote was for about $100,000 — 25 per cent of the $250,000 voted by the Federal Parliament, and a balance of some thirty thousand dollars due under a previous Agreement.

Mr. Ross said that such an amount as $125,000 would be required only if a satisfactory carbonizer were secured and the Board were authorized to purchase material — coal, binder, etc.

It was understood that before the sum of $125,000 should be advanced the Governments should be consulted again, Dr. Camsell asking that if possible the Board should report its estimated requirements in time to draw whatever amount is necessary before the end of the Federal fiscal year, so that another vote would not need to be put through the House.

Speaking for the Governments they represent, Dr. Camsell, Premier Dunning and Premier Bracken agreed to advance their share of the expenditure entailed by the programme which they had authorized at this Conference, it being understood that no expense should be put on the plant without further authority.

The members of the Board agreed with Premier Dunning that a fairly full report as to the possibilities of the Hood-Odell retort could be made within three months, Mr. Ross adding that the total cost of three months' shut down of the plant would probably be about $10,000, and he estimated that the experimental work would not entail a greater expenditure than an additional $5,000.

One of the members of the Board suggested that the date be set now for the next Conference, but Premier Bracken pointed out that this would depend on the reports received from the Board. Dr. Camsell agreed that another Conference should be held, but thought it would not be wise to set the date at this time. Premier Bracken remarked that it was understood that there would be another Conference before any additional money was advanced.

§

APPENDIX 13

Report by Lignite Utilization Board, July 27th, 1923.

288, ST. JAMES STREET,
MONTREAL, *July 27, 1923.*

THE HON. CHARLES STEWART,
Minister of Mines,
Department of Mines,
Ottawa, Ont.

THE HON. JOHN BRACKEN,
Premier — The Province of Manitoba,
Manitoba.

THE HON. CHARLES DUNNING,
Premier — The Province of Saskatchewan,
Saskatchewan.

Sirs:—

The Lignite Utilization Board begs to submit the following special report and recommendations treating solely of the Hood-Odell oven and future policy based on the result of work to date, on the occasion of a conference held in Winnipeg on July 30, 1923, between the three Governments and the Board. It is divided into the following heads:—

I ACTION TAKEN AT WINNIPEG MEETING, MARCH 3, 1923.
II PRESENT SITUATION :
(a) CONSTRUCTION AND OPERATION
(b) FINANCIAL.
III RECOMMENDATIONS.

I ACTION TAKEN WINNIPEG MEETING, MARCH 3, 1923.

On March 3, 1923, a meeting was held in Winnipeg, where representatives of the Federal Government, of the Manitoba Government, of the Saskatchewan Government, and of the Lignite Board, met to receive reports on the experimental operations conducted in the Hood-Odell oven at Grand Forks on Saskatchewan lignite. At that meeting the Lignite Board reported on a number of matters, of which report the following is a rough digest:—

(1) The Hood-Odell oven as developed at Grand Forks was not yet out of the experimental stage but the amount of success attained warranted the erection at Bienfait of a revised oven of the same type, and that this oven should be operated for roughly a six months' period.

(2) That the cost of making this test would be about $40,000 and that the amount of money the Board then had on hand was $24,000, (when the books were closed at the end of February this balance turned out to be about $23,250). As a result of this meeting the Board was authorized to proceed with the erection of one Hood-Odell oven at Bienfait, and to expend on the same and its operation the sum of $24,000. The Governments agreed to furnish the remaining $125,000 and to place it to the credit of the Lignite Board for possible future experimental work, with the distinct understanding however, that it must not be expended without further authorization from the three supporting Governments.

II PRESENT SITUATION.

The Lignite Board begs to report the following:—

(a) *Construction and Operation:* As soon as possible after the Winnipeg meeting, arrangements were concluded with the American Bureau of Mines, Washington, to act in the capacity of consulting engineers. Drawings for the new oven were prepared and on March 19th and 20th, Mr. Odell

was in Bienfait consulting with Messrs. Roche and Strong on the exact details of the proposed oven. A unanimous decision was reached, and as a result drawings were prepared in Washington by the Bureau of Mines, which drawings reached us by about the middle of April, 1923. Quantities and estimates were then taken off, and, where necessary, orders placed for new material. The erection of the oven was completed by the middle of June. The date of completion was three weeks to a month late, owing to a misunderstanding between the American Bureau of Mines, Washington, and Department of Mines, Ottawa. After some preliminary tests, the oven was fired on Monday, June 25th. It was operating steadily until July 3rd, when it was suspected that during the night some of the baffles had been burned out, due to over-heating. The oven was then stopped, emptied and cooled, when it was discovered that four baffles had been melted, and a few others were slightly damaged.

The oven was thereupon shut down and orders were placed for new cast iron baffles. As soon as possible minor changes and repairs were made as follows:—a smaller pulley was placed on blast fan motor in order to reduce fan speed, better facilities were installed for cleaning gas offtake, discharge paddle was moved closer to discharge opening, etc., etc. These changes were made and the new baffles had been installed by July 12th. On July 13th the retort was started up again, and during its operation the gas was removed by exhauster, etc., through the ordinary gas system.

RESULTS.

Period of {June 25th to July 3rd inclusive and July 13th to July 25th inclusive}
Total lignite charged — 532 tons
Total char recovered — 227 tons

Average analysis of char

Moisture...................... Nil
Volatile Matter................ 12.2
Ash........................... 15.1
Fixed Carbon.................. 72.7
B. T. U....................... 11,500 (Not an average result)
Gas available — 15,800 cu. feet per ton.
B. T. U. (average) 100.
Gas at present being burned in boilers 9,170 cu. feet per hr.
(This equivalent to 1.6 tons of coal per day).

REMARKS.

Since July 13th, the oven has been operated continuously, and the result has been very encouraging. Within its own limits it produces char regularly. The limits referred to are the necessity for charging coal of a certain screen analysis, the special nature of the gas possible to recover, and the necessary increase of the ash content of the char. In spite of these conditions, however, the char produced is suitable for briquetting in the future, and the Board is hopeful of being able to sell the surplus as a producer fuel in the immediate future.

The life of the oven can not be predicted at all but the present difficulties with leakages, baffle deterioration, clinkering, etc., appear to be remediable.

(b) *Finance:* Since March 1st, the following has been the total expenditure of the Board, with estimate of July expenses.

	Administration Montreal and Plant	Travelling	Capital and Operating	Misc.	Total
March	$1,835	$159	$1,689	$ 12	$3,695
April	1,906	141	1,267	...	3,314
May	1,954	198	1,394	204	3,750
June	1,818	45	3,492	4	5,359
July (est'd only)	1,900	275	5,992	100	8,267
Totals	$9,413	$818	$13,834	$320	$24,385

In the foregoing figures the following is directly chargeable to the Hood-Odell retort with July distribution estimated, and with no overhead charged to the oven directly:—

Capital.........................$4,045
Operating...................... 3,065 Straight labour plus supplies.
Misc........................... 260

$7,370

In order to make the 6 months' test referred to during the March Meeting, it would be necessary to operate the oven for another 4 months at about $6,500 a month which is $26,000. This makes a total of about $50,000. The apparent excess is due to the fact that we have not included any allowance for sale of char, which may reasonably be expected to yield an amount in the neighbourhood of $3,500. Secondly, it is to be remembered that we are a month behind-delay occasioned by the misunderstanding between Ottawa and Washington. This would involve the carrying of the overhead of the Board for a month amounting to about $3,500.

III RECOMMENDATIONS:

The Board recommends that this meeting approve the following programme:

(i) That the present oven be operated in any event until Nov. 1st, 1923, and later if adequate sale at commercial figures can be achieved for product, and that, during operation, it be used to determine experimentally the solution of present troubles with gas leakages at top and bottom, the suitability of hoods, the accessibility for baffle repairs, and suitability for operation in winter.

(ii) That orders for material for four Hood-Odell ovens be placed almost immediately, said new ovens to be erected in the present carbonizer building, during operation of existing oven, but that construction be deferred until the success of experimental programme be established as in Paragraph one.

(iii) That revisions to briquetting building be proceeded with as soon as possible, in order that when new ovens are ready to operate, the briquetting equipment may also be ready.

The general financial aspects of these three recommendations are as follows:—

CARBONIZING				BRIQUETTING			
Description	Time of completion	Cost		Description	Time of completion	Cost	
		Capital	Operating			Capital	Operating
Run present oven till.	Nov. 1		$20,000 including overhead	Paper layouts	Sep. 15	$250	Covered
Cost of positive exhauster say........		$3,500		Revisions and machinery changes in roof, piping etc.	Dec. 1	$20,000	$1,800
Cost of 4 new ovens at $3,500..........	Nov. 15	$14,000	$1,800				
Cost of tearing down part of existing ovens, piling material say $600..........	Sep. 15	$2,400	Covered				
Cost of conveyors, belts, and changes in car. bldg..........		$1,500	Covered				
Totals required...		$21,400	$21,800			$20,250	$1,800

Plus contingencies at 15%..	9,750
Total..	$75,000

Note that total overhead beyond Nov. 1st., is only $3,600. Compare with overhead of $3,600 a month (4 x 3,600 =$14,400) and frost troubles if whole project were held up until Nov. 1st, and then a 4 or 5 months' wait.

Respectfully submitted,

R. A. Ross,

Chairman.

—§—

APPENDIX 14

Copy of Memorandum to the Hon. Chas. Stewart dated Sept. 14th, 1923.

OTTAWA, ONT., *Sept. 14th, 1923.*

HONOURABLE CHARLES STEWART,
Minister of Mines,
Ottawa, Ont.

Dear Sir:

As a result of the meeting this morning in your office, the Lignite Board in view of the financial condition of the lignite project, brought about by the withdrawal of Manitoba, accedes to your request to submit a suggestion for immediate action.

As the available funds as at October 1st, 1923, appear to be about $75,000.00, the Board would suggest that the work can be advanced with a minimum of delay and expense by instituting immediately the following programme.

1. A three months' period of operation of the present single Hood-Odell oven, together with revisions to the briquetting plant. During this time the char is to be stored.
2. At January 1st the oven be closed down, and a three months' period of briquetting runs be undertaken, using the char accumulated during the period October 1st to December 31st.

The financial aspects of this programme are:

Capital Expenditure....................................	$30,000.00
Six months operating expenditure........................	42,000.00
	$72,000.00
Contingencies...	3,000.00
	$75,000.00

The above figures take no account of any returns from sale of the several hundred tons of briquettes that should be made during the second period.

The foregoing is submitted not as the programme desired by the Board, which programme was outlined in our report of July 27th, 1923; but merely as a programme that will in all likelihood give the maximum of results by the expenditure of the sum available.

Believe me to be,

Very truly yours,

R. A. Ross,

Chairman.

—§—

APPENDIX No. 15

DEPARTMENT OF MINES, OTTAWA, APRIL 25, 1917.

Report on the Investigation Concerning the Briquetting of Lignites in the United States and Canada.

DR. EUGENE HAANEL,
Director of Mines Branch,
Dept. of Mines, Ottawa.

Sir,—

I beg to submit, herewith, for transmission to the Chairman of the Advisory Council of the Commission of Industrial and Scientific Research, the observations and recommendations resulting from my investigation concerning the briquetting of lignite coals.

INTRODUCTORY.

In order to gain a comprehensive knowledge of the status of the lignite briquetting industry in the United States and Canada, it was necessary to obtain, as far as possible, all data concerning the various plants erected for both experimentation and demonstration of the various methods and processes advanced from time to time. This implied the necessity of visiting those plants which were still in operation, and the research laboratories engaged in the solution of this and allied problems.

Efforts to briquette lignites have been made by different parties and companies, both in the United States and Canada, but for the purpose of this report it is only necessary to mention the work of those who have seriously attacked the problems involved. The following are the principal companies still operating, and the plants erected for experimental purposes: The American Coal Reduction Company of Denver; the experimental plant of the University of North Dakota; the carbonizing plant situated at Minot, North Dakota; the plant erected at Estevan, Saskatchewan, by the Government of Saskatchewan for the purpose of demonstrating the commercial applicability of a process for treating Canadian lignites advanced by Mr. S. M. Darling, and, finally, the laboratories of the Malcolmson Briquette Engineering Company.

PLANTS VISITED.

Of the above plants, the American Coal Reduction Company is the only one where an attempt is being made to conduct the carbonization of lignite on a commercial scale, and briquette the carbonized residue, but since the lignite at this plant is carbonized principally for the recovery of certain valuable oils and the carbonized residue which is briquetted is termed a by-product, this plant and the process employed is of no particular interest as regards the briquetting of Canadian lignites. Moreover, the coal utilized, while termed a lignite, is very dissimilar to the lignites of Saskatchewan.

The experimental plant maintained at Hebron, North Dakota, by the University of North Dakota, was the outcome of certain research work conducted by Professor Babcock and his associates concerning the briquetting of the North Dakota lignites. This plant is, however, only operated on special occasions and will not be in condition for inspection until July. The method worked out by Professor Babcock consists essentially in the carbonizing of the lignite in specially designed retorts, and the briquetting of the carbonized residue. The process of carbonizing is accompanied by recovery of valuable by-products, such, e.g., as oils, tar, and ammonia. So far, this process has not been applied successfully on a commercial scale.

At Minot, the writer was informed a commercial plant was erected for the purpose of putting into effect the principal features of the Babcock Process, where the lignite was carbonized in a series of bee hive ovens, but this venture proved unsuccessful, and this plant is now abandoned.

WORK ATTEMPTED IN CANADA.

The only attempt made so far in Canada to establish the briquetting of lignite on a commercial basis was that of S. M. Darling, under the auspices of the Saskatchewan Government. A small plant was erected at Estevan for the purpose of demonstrating the economic possibilities of this process. In fact there was no thought entertained by the inventor concerning its possible failure to meet commercial application and conditions, but like all the others this experimental plant is now abandoned, and the problem concerning the briquetting of lignites is no nearer a successful solution.

FACTORS ON WHICH DEPEND SOLUTION OF PROBLEMS INVOLVED.

It is necessary to point out at this juncture the fact that, in all methods and processes so far advanced and which have given any promise of success, the problem has been attacked from only one point, viz., the carbonization of the lignite, but little, if any, attention was given to the briquetting of the carbonized residue. This is, as I will point out later, partially responsible for the failures so far recorded, and the fact that no lignite briquettes are now being manufactured either in the United States or Canada, with the one exception of the fuel briquettes manufactured by the American Coal Reduction Company of Denver, Colorado.

In passing, it may be well to lay stress upon the most important and difficult problems, entailed in the briquetting of the carbonized product, and the extreme lack of knowledge or information concerning this most important feature disclosed by nearly all the investigators who have made efforts to briquette lignite.

PRINCIPAL FIRM ENGAGED IN SOLVING BRIQUETTING PROBLEMS, ETC.

The only firm of engineers who have investigated the briquetting of the different true coals and, to a large extent, lignites, from the logical standpoint and according to scientific methods, is the Malcolmson Briquet Engineering Company. The work accomplished by this firm will be discussed later.

PROBLEMS INVOLVED IN BRIQUETTING OF FUELS.

A comprehensive idea concerning the many and difficult problems encountered in the briquetting of lignites cannot be gained without a knowledge of the properties and characteristics of this fuel. Lignite, under the action of the air and heat, possesses the property of disintegrating. This disintegration appears to be indefinite. In the case of true coals, the subdivision of the solid mass into small particles or grains ceases when the extraneous mechanical force which produced this physical change is removed, and herein lies the great difference exhibited by the two types of fuel so far as their amenability to briquetting is concerned.

PROPERTIES OF LIGNITIC COALS.

It is well known by all conversant with the peculiarities of lignitic coals in general that one of the chief characteristics of this type of coal is the high moisture content, attaining in certain cases as high a percentage as 35. It is further pretty common knowledge that, on weathering and drying in the open air, lignites rapidly disintegrate, but the fact that this disintegration proceeds after the free moisture is entirely removed is not so well known, and this is a most important characteristic, which should be understood from every phase before any attempt is made to devise a process for briquetting.

When crushed or slack bituminous coal or anthracite is thoroughly mixed with a suitable binder and briquetted, the mass becomes a cohesive whole, stands up under a hot fire, and does not crumble or disintegrate when exposed to the weather. In the case of crushed lignite, however, when mixed with the same binder and briquetted in the same manner, the briquettes, when subjected to heat, disintegrate, and fall into a powder.

NECESSITY FOR ALTERING CHARACTERISTICS OF CARBON IN LIGNITIC COAL.

In order to overcome this difficulty, it was recognized by all investigators that the characteristics of the carbon of the lignite must be altered, and this is accomplished by carbonization. Carbonization results in the removal from the lignite of all moisture and practically all of the volatile matter, an excess of 4 to 5 per cent volatile matter being prejudicial to the manufacture of a suitable briquette.

PROBLEMS PRESENTED IN CARBONIZATION OF LIGNITE.

RETORT OR OVENS TO EMPLOY.

The carbonizing or carbonization of the lignite does not present any difficult problems, and any standard coking retort, altered to meet the conditions obtaining, can be employed. Since the object of carbonizing is to remove all the moisture and volatile matter from the fuel, it is self-evident that a retort or oven which is suitable and efficient for coking, where practically the same conditions prevail, will be suitable for lignite. Hence the writer is of the opinion that this phase presents no difficulties which cannot be easily overcome, and it can, therefore, be dispensed with without further comment.

BRIQUETTING OF CARBONIZED RESIDUE.

The briquetting of this carbonized residue is the most important phase of the process, since it is here that problems of a most difficult nature are met and must be solved before a commercial briquette can be placed on the market. Before proceeding further, it is necessary to indicate the properties a briquette must possess in order to meet all the commercial conditions and requirements:—

1.—It must be waterproof and stand up when exposed to the weather.
2.—It must be capable of standing rough handling without breaking or producing fines.
3.—It must maintain its physical structure or shape under the action of heat until completely consumed.
4.—It must produce no more smoke than the coal with which it must compete.

The imparting of the above properties to a briquette made of carbonized lignite depends entirely on the method of procedure followed in briquetting, and the method employed, to be successful, must be based on results obtained from careful and intelligent research work on other coals as well as lignite, and on the experience gained from the many failures attendant upon the successful solution of the problems encountered in briquetting the true coals.

The problems to be solved in the case of lignite are not in a general sense dissimilar to those which have been successfully met in the briquetting of true coals, but the properties of carbonized lignite are in certain cases quite different, and the problems introduced by these dissimilarities must be worked out independently and by themselves.

FACTORS UPON WHICH DEPEND THE BRIQUETTING OF ANY FUEL.

In general, it may be said that the production of a commercial briquette of any fuel depends upon the following factors:—

1.—Uniform size of the particles composing the crushed fuel, and the most suitable degree of fineness.
2.—The binder or binders with which the crushed fuel is mixed.
3.—Method of mixing the binders.
4.—Type of briquetting press.
5.—Method of waterproofing briquette.

1. The uniform size of the particles composing the fuel is of sufficient importance to warrant particular attention on the part of those attempting the briquetting of a fuel, since the binder, in order to serve its function of securely holding together the minute particles of the fuel, must thoroughly cover the surface of all the fine grains. It is evident, therefore, that any marked differences in the size or physical shape of the grains or particles will produce more marked differences in the extent of surface to be covered by

the binder, and if the crushed or disintegrated fuel is in no sense homogeneous, i.e., is composed of particles varying from very fine to very coarse, it will be easily seen that the quantity of binder mixed with this fuel will be unevenly distributed, and this will result in a weak briquette. There is a limit, however, to the degree of fineness to which the material composing the briquette can be reduced, and this is fixed by the quantity of binder the process will permit to be employed without rendering it uneconomic. The finer the grains composing the reduced coal, the greater the quantity of binder required to completely cover the surfaces of the particles and produce an intimate mixture.

2. The binders employed are governed first, by their suitability for the purpose required, and second, by the cost and the quantity available. The binders commonly employed in briquetting coals are: coal tar pitch or liquid tar, petroleum, asphaltum, or a mixture of the two, but latterly sulphite liquor, which is produced on an enormous scale both in the United States and Canada, and for which there is little or no demand at present, is looked upon with great favour as a binder for the briquetting of fuels in general. This waste by-product of the sulphite pulp mills possesses, when concentrated to a 50 per cent solution, that is, 50 per cent solids, all the properties required of a binder when specially treated. Sulphite pitch is soluble in water, and, therefore, the briquette must be specially treated to render the binder waterproof. In the case of this type of binder, water-proofing is accomplished by heat treatment.

3. The method employed for mixing the binders is of great importance. Fuels briquetted under almost identical conditions have made good or bad briquettes, depending on the method and manner of mixing the binder. This is one phase of the process which must be carried out according to the vast experience gained by the investigators and engineers who have carried to successful completion the briquetting of true coals. This experience and the results obtained at great expense are, however, not given to the public, but constitute the capital of the individuals or companies who have achieved success.

4. The type of briquetting press employed has, in many cases by bad selection, been a powerful factor in preventing many otherwise sound briquetting propositions from attaining success. In many cases those desiring or contemplating the erection of a fuel briquetting plant — in this country and the United States — have turned their attention to the European countries where so much has been done, and such marked success attained in the briquetting of fuels. But in many, if not almost every case, the conditions prevailing on this continent were not taken into serious consideration. The types and capacities of European presses, and the size and shape of the briquette made, while eminently suitable in European countries, failed absolutely when employed under the conditions obtaining on the American continent. For this reason alone the fuel briquetting industry has had a slow and backward career, attended by the loss of much capital and the confidence of the men engaged in the fuel business.

The problems involved in the design and manufacture of a briquetting press suitable for the conditions obtaining on this continent have been successfully solved. These problems may be briefly stated as follows: large capacity with the lowest possible wear and tear on the machine, method of maintaining the requisite pressure uniform and for long periods, automatic feed of the fuel to the rolls, and finally capability of furnishing to the market a briquette of the most suitable size and shape. All these conditions have been met and are embodied in one of the principal briquetting presses manufactured in the United States.

5. The method employed for water-proofing a briquette made with sulphite pitch as a binder is that of baking at a certain temperature in a specially designed and constructed retort or oven. In the case of anthracite coal the problem of waterproofing the briquette according to this method has been successfully solved, after many discouragements and the expenditure of much money. Carbonized lignite, however, will not withstand the same temperature that anthracite coal will in the baking retort, on account of incipient fusion which is likely to take place. This is due to peculiar characteristics possessed by this fuel. The apparatus employed in the one case can, however, by slight and suitable alterations, be made to work equally well with lignite. This most important phase of the problems involved has been satisfactorily worked out by the Malcolmson Briquet Engineering Company, and is at present being employed in the large one million ton anthracite culm briquetting plant now in course of erection at Norfolk, Va.

ECONOMIC PROCESS FOR THE BRIQUETTING OF LIGNITES.

The briquetting of Saskatchewan lignites involves, in general, the following steps:—
1st. Primary heat treatment — carbonization of the raw lignite.
2nd. Crushing carbonized residue to uniform grains.
3rd. Mixing carbonized residue with binder.
4th. Briquetting mixture of carbonized lignite and binder.
5th. Secondary heat treatment — baking to make briquette waterproof.

DISCUSSION OF STEPS TO BE EMPLOYED IN BRIQUETTING LIGNITES.

The writer is of the opinion that none of the above steps offer any problems of a character which cannot be successfully and easily solved with the aid of the large amount of experience and valuable results at the disposal of the engineering firm which has made a special study, covering over 12 years, of the various problems presented in the briquetting of fuels. Certain problems of a minor nature will arise, such, e.g. as the most suitable and economic binder to employ, and method for mixing fuel and binder. It may prove necessary to mix coal with the carbonized lignite but an investigation now being conducted by the Malcolmson Briquet Engineering Company at their laboratories with carbonized lignite obtained from Estevan, Saskatchewan, indicates that such an addition of coal will be unnecessary.

SULPHITE LIQUOR A SOURCE OF BINDER.

Sulphite liquor, which is being produced annually on a very large scale, and which at the present time is a waste product, will, it is believed, solve the problem of a satisfactory binder. Petroleum residue — asphaltum — while known to be an excellent binder, cannot enter into the composition of Canadian briquettes, on account of the excessive cost per ton delivered to almost any point in Canada. Coal tar pitch is available in comparatively large quantities, but does not produce as satisfactory a binder as sulphite pitch. The liquid tar formed during the process of carbonization of the lignite at any plant established for the briquetting of Canadian lignites should be recovered and used as far as possible in the formation of the briquette for the purpose of reducing the quantity of sulphite pitch necessary to mix with the carbonized material, and thereby reduce the cost of the binder.

PERCENTAGE OF SOLIDS IN SULPHITE LIQUOR.

Sulphite liquor as produced in the various pulp mills contains, on an average, 10 per cent solids, and these solids, composed of the resins and lignins from the wood, constitute the active binding matter desired. In order to use sulphite liquor as a binder, it is necessary to concentrate it to a fifty per cent

solution, i.e., a solution containing 50 per cent of the above solids. A process is in operation, at the present time, which economically reduces the solid matter of the liquor to a bone dry powder. In such a form, the solid matter of the liquor possesses many advantages, among which may be mentioned ease of transportation, as against the shipment of the concentrated liquor in barrels or tank cars, and low freight costs. Both these items attain much importance when the briquetting plant is situated a considerable distance from the source of the sulphite liquor — and this is the case regarding the Saskatchewan lignites.

CONCENTRATION OF SULPHITE LIQUOR.

Since it is necessary to erect a special plant, at some logical point, for the concentration of sulphite liquor, or its reduction to a dry powder, before the Canadian liquor can be made available as a source of binding material for briquettes, a plant for briquetting, erected at the present time, i.e., in the course of a few months, would have to depend on imported sulphite pitch.

REASONS FOR PAST FAILURES OF BRIQUETTING PLANTS.

The many past failures of attempts to establish the briquetting of solid fuels on a commercial basis have almost without exception resulted from the lack of foresight displayed in not enlisting the services of those who have made the briquetting of fuel a business, and who have attacked the problem logically and scientifically from the beginning, and who, as a result, have gained a vast and valuable experience concerning all the intricate problems involved. A lack of sufficient capital to carry to completion certain of the more promising undertakings has also been a contributing factor to the many failures.

CONCLUSIONS AND RECOMMENDATIONS.

In conclusion, I may state that my observations regarding the investigation concerning the status of the lignite briquetting industry in the United States, disclosed the fact, that while many attempts to briquette fuels have been made, only one firm has succeeded in erecting commercial plants, and in solving the many complex problems associated with the briquetting of anthracite and bituminous coals. This firm is the Malcolmson Briquet Engineering Company, Old Colony Building, Chicago, and also of New York. Mr. Chas. T. Malcolmson, the President of the firm, was for some time the chief engineer of the Fuel Testing Division of the United States Bureau of Mines, and during his incumbency in this position carried out many experiments concerning the briquetting of the various United States coals. His reports disclose the fact that in all some thousands of tons of United States coals were briquetted with various well known presses, using different binders or mixtures of binders and also under many varied conditions. The experience gained by his investigations and practical work along these lines led him, some twelve years ago, to enter the briquetting industry commercially, and the present company is the result of that venture. Since the formation of the above company, he has been almost directly responsible for the successful construction of the Berwind coal briquetting plant, situated at Superior, Wisconsin, the million ton anthracite fuel briquetting plant situated at Norfolk, Virginia, and a large coal briquetting plant in California. The successful conclusion of the investigations and experimentation resulting in the erection of the Berwind plant cost in the vicinity of 500,000 dollars, and the information thus gained through this, as well as through many other efforts, is now available for the erection of other plants involving similar problems.

In addition to the work accomplished in the devising of processes, and the design and erection of large commercial plants, this company has and is carrying out extensive investigations concerning the low temperature carbonizing of fuels, including lignites, and the methods to be employed in utilizing sulphite liquor as a binder.

This firm of engineers is in a position to design and construct a plant for the carbonizing and briquetting of lignite fuel, and I would, therefore, respectfully recommend that this firm be employed in the capacity of Consulting Engineers and Contractors, if it is desired to have a plant for the briquetting of Saskatchewan lignites erected and put upon a commercial basis in the shortest space of time.

I am appending to this report (Exhibit A) a copy of a letter received from Mr. Malcolmson, in which he states the case as it appears to him. This firm is now preparing a detailed estimate of cost of plant, etc., and is also conducting a special investigation concerning certain problems presented in the briquetting of Saskatchewan lignites. These data I expect to receive in a short time.

Respectfully submitted,
(*Sgd*) B. F. HAANEL,
Chief Engineer,
Division of Fuels and Fuel Testing.

GBE

EXHIBIT "A" OF MAIN APPENDIX 15

Malcolmson Briquet Engineering Co.

Consulting and Contracting Engineers,
Old Colony Building,
Chicago.

CHICAGO, *Apr. 9, 1917.*

MR. B. F. HAANEL,
Chief Engineer, Division of Fuels and Fuel Testing,
Department of Mines,
Sussex Street, Ottawa.

Dear Sir,—

We desire to confirm various conversations with you in regard to a plant which it is proposed shall be constructed in Saskatchewan for the carbonization and briquetting of lignite.

The briquetting of lignite presents problems which are not encountered in the briquetting of true coals. This is due to the fact that raw lignite rapidly disintegrates upon exposure to the air and in consequence any bond or binder used in cementing the particles together becomes ineffective. In Europe the raw lignite is dried and briquetted under high pressure and heat. Exhaustive experiments have been made in this country to duplicate these results with American lignites, but such results as were obtained were not satisfactory.

The European lignites are of different origin from the American lignites and contain a considerable quantity of "bitumen" which becomes active under pressure and heat in cementing the particles together. There is a small deposit of similar lignite in California and it has been demonstrated that the quality of German briquets can be approximated in briquetting this lignite after the German process. Texas and North Dakota lignites, however, do not respond to this treatment.

It becomes necessary therefore, to change the characteristics of the carbon in the lignite before briquetting and this is accomplished by carbonization. A great deal of experimental work has been done by ourselves and others in this country during the past fifteen years along this line, but up to the present time no satisfactory commercial fuel has been produced. Attempts have been made to briquet the carbonized and raw lignite by the addition of coking coal, but briquets so made have been satisfactory only when there was a preponderance of coal in the briquets.

The perfecting of a plant for the production of commercial briquets made from American lignites has always attracted the attention of promoters and in consequence a great many plants have been built which have failed because of the lack of adequate knowledge of the problems involved. A striking parallel is found in the history of the coal briquetting industry in this country. Not until sufficient capital and the proper connections and organization were provided was it possible to establish a coal briquetting plant on a sound commercial basis. Until the same careful study is given to the lignite problem and the same resources are made available, the lignite problem will not be solved; and this, in our opinion, is the reason no successful commercial plant for the briquetting of lignite has been established.

You will understand that in all the above processes attempted in this country binders have been used, following the general practice of briquetting true coals. The question of binder is of prime importance. The binder must have either the property of coking or of producing a coke out of the material briquetted; or the binder must not soften under heat and allow the briquet to disintegrate until the briquet is entirely consumed in the fire.

We are informed that a large quantity of sulphite liquor goes to waste annually in Canada and that this can be made available as a binder; that it is also possible to obtain coal-tar pitch in limited quantities. If necessary these binders can be imported from the United States until they can be produced in Canada.

We desire to define at this point what we mean by commercial briquets; First, — They must withstand abrasion and breakage in transportation; Second, — They must not disintegrate when stored in the open; Third, — They must hold together in the fire until consumed; Fourth, — They must produce no more smoke than coals with which they must compete. In making such comparisons it is necessary always to qualify our statements by comparing the properties of the briquets with similar properties of coals which are sold in the same market.

We understand that you are considering a plant of twenty (20) short tons per hour capacity. Our recommendation is that a plant of this size should include two complete units each of half this capacity and that one unit be installed at the present time. We recommend further that the buildings and equipment common and necessary to the operation of both units be installed now. A complete unit shall include one briquetting press and auxiliary briquetting machinery; carbonizing and heat-treating plant.

The design for the plant as above outlined shall include a standard carbonizing retort, preferably of the vertical continuous type. The standard design will probably have to be modified to suit your conditions, but this will not involve any serious problems in designs, construction or operation.

The briquetting plant proper will be designed to utilize either dry or liquid binder and will include our standard machinery which has been worked out for this purpose. In all probability the briquets will weigh approximately 2 oz. each and will be of approximately the same size as anthracite nut coal.

When using sulphite liquor or other organic binders, soluble in water, it is necessary that briquets so made shall be treated to make them waterproof. We have devised a furnace for the waterproofing of briquets made of anthracite coal and sulphite liquor. This furnace will be modified to suit your conditions as lignite carbon will not withstand as high temperatures as anthracite coal.

We shall be pleased to furnish you within the next two weeks a preliminary estimate of the cost of such a plant erected at or in the vicinity of Estevan. It will require from six to eight months to build this plant after the contract is signed. Our estimate is based on the assumption that we can begin work early enough this spring to put in the foundations and erect the buildings during the summer; also our ability to obtain from the St. Louis Briquette Machine Co. a press of the proper size which is now under construction.

We have carried on a great many laboratory experiments to determine the proper treatment in briquetting American lignites and our conclusions indicate that while the problem is not an easy one there are no insurmountable difficulties to be overcome. What will be required is the application of our experimental results to a commercial plant. The situation to-day does not present as many difficulties as we found ourselves facing when we built the first Berwind Plant at Superior, Wis., for the manufacture of coal briquets. Since that time we have perfected our briquetting machinery and have accumulated invaluable experience and information in the commercial operation of these plants. The real problems in the production of commercial briquets center about the briquetting of the carbonized lignite, as our experience indicates the carbonization or preliminary heat-treatment of the lignite offers no unusual problems.

We are prepared to enter into a contract with the Canadian Government, or some responsible person or corporation, to act as their consulting engineers, and to design and construct for them a complete plant for the carbonization and briquetting of Saskatchewan lignites. You have been reliably informed of our reputation and experience in the development of the coal briquetting industry in this country. We could not afford to attack your problem if we were not reasonably sure that it can be carried to a successful conclusion.

Yours very truly,

MALCOLMSON BRIQUET ENGINEERING CO.
Sgd. C. T. MALCOLMSON,
President.

APPENDIX No. 16

Report on Trip of Inspection of Low-Temperature Carbonizing, Briquetting and Powdered Fuel Plants

November 11, 1918,
to
January 11, 1919.

R. DeL. French
and
Edgar Stansfield.

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REPORT.

List of Illustrations.

Note.

The diagrams and sketches accompanying the appendices to this report are not to scale and are intended to illustrate the principles of the various processes, etc., to which they refer, rather than to serve as drawings of actual apparatus. For this reason, considerable liberties have sometimes been taken with the arrangement of details.

MONTREAL, *February 22, 1919.*

THE LIGNITE UTILIZATION BOARD OF CANADA,
80, St. Francois Xavier St.,
Montreal.

Gentlemen:—

We submit herewith a brief account of our trip of inspection, undertaken on behalf of your Board, and lasting from November 11, 1918, to January 11, 1919.

We visited the following cities in the order in which they are given:—

New York, N.Y.	Champaign, Ill.	Moose Jaw, Sask.
Trenton, N.J.	Chicago, Ill.	Estevan, Sask.
Newark, N.J.	Milwaukee, Wis.	Bienfait, Sask.
Philadelphia, Pa.	Kansas City, Mo.	Winnipeg, Man.
Lansford, Pa.	Denver, Colo.	Grand Forks, N.D.
Wilkes-Barre, Pa.	Seattle, Wash.	Duluth, Minn.
Scranton, Pa.	Renton, Wash.	Superior, Wis.
Dickson City, Pa.	Vancouver, B.C.	Sault Ste. Marie, Ont.
Harrisburg, Pa.	Ioco, B.C.	Sarnia, Ont.
Pittsburgh, Pa.	Port Mann, B.C.	Chicago, Ill.
Washington, D.C.	Bankhead, Alta.	Detroit, Mich.
Norfolk, Va.	Medicine Hat, Alta.	London, Ont.
Parrott, Va.	Regina, Sask.	Toronto, Ont.
Louisville, Ky.	Saskatoon, Sask.	

As instructed by your Board, we endeavoured to interview all persons who were interested in the carbonizing or briquetting of coals, and in the use of pulverized fuel, or whose interests touched in any manner upon these or allied matters. We were received with uniform and exceptional courtesy by all the gentlemen upon whom we called, and were freely supplied with all the data at their disposal, some of which is highly confidential.

We also visited all the low-temperature carbonizing plants of which we had any knowledge, and we believe we inspected every briquetting plant now in operation in the United States or Canada, with the exception of a small one at Tweed, Ont. Beside this, we inspected a number of briquetting plants which have not been in operation for some years, principally with a view to ascertaining whether or not any of their equipment would be suitable for the Board's purposes.

Advantage was also taken of the opportunity of paying visits to such plants as were burning pulverized coal as could be conveniently reached without too much dislocation of our itinerary.

The Secretary of the Board, Mr. Lesslie R. Thomson, has published from time to time in his Executive Circulars, the names of those with whom we had interviews, as well as a list of the plants visited. It therefore seems unnecessary to repeat these here.

We have endeavoured to run down to its source every item of information which might be construed as having any bearing upon the Board's projects. Of course, a great deal of the time spent in this manner has proved in one sense to have been wasted, as the information finally obtained was of little or no value. On the other hand, a large number of clues, picked up in interviews, led to the acquisition of information which we consider to be of value.

Attached hereto are three appendices, viz.,—

Appendix A. — Comments on low-temperature carbonizing processes inspected.
Appendix B. — General description of briquetting plants inspected.
Appendix C. — Memorandum on the present status of the use of pulverized fuel.

This report is admittedly incomplete. Our investigations thus far have convinced us that before any definite steps can be taken leading to the erection of a plant for the carbonizing and briquetting of Saskatchewan lignites, there remains a considerable amount of work to be done. The following should be undertaken immediately:—

1. Determination of the quantity of heat required to complete carbonization at any temperature, and of the rate at which any desired degree of carbonization may be effected by exposure to different temperatures.
2. The operation of a rotary carbonizer (already available) and the construction and operation of a shaft retort in order to accumulate data upon which to base the designs for full-sized apparatus.
3. The acquisition and operation of a small mixer and roll press to determine the minimum mixing ratio and maximum rate of operation compatible with the production of a satisfactory briquette.

   The determination of these optimum conditions should include a study of

   a. — Temperature of carbonization of the lignite.
   b. — Fineness of material.
   c. — Nature of binder.
   d. — Method of mixing and fluxing.

4. The heat treatment of briquettes to produce a smokeless fuel, and the construction and operation of a suitable furnace or oven for this purpose.

The following further experiments should be made as opportunity offers:—

5. On the weathering and storage of raw, air-dried, oven-dried and carbonized lignite.
6. On the use of dried and carbonized lignite as a powdered fuel.
7. Such further experiments on carbonizing and briquetting as there may be time for, before the removal of the experimental equipment to the permanent commercial plant, to the end that experimental and adjustment work with the latter may be reduced to the minimum.

Concurrently with the above investigations, partial layouts should be prepared. These may point the way to the path of commercial practicability, and in any event will be of value when the final design is undertaken.

All of which is respectfully submitted.

(*Sgd*) R. DEL. FRENCH,
Engineer.

(*Sgd*) EDGAR STANSFIELD,
Chemical Engineer.

APPENDIX A OF MAIN APPENDIX 16

COMMENTS ON LOW-TEMPERATURE CARBONIZING PROCESSES INSPECTED.

There is very little definite information in existence as to the best methods of carbonizing coals at low temperatures, though much experimental work is now being done along these lines. It may be stated at the outset that hitherto all low temperature carbonization of coal has had for its primary object the production of the maximum quantity of by-products, and that the yield of coke or residue has been a secondary consideration. On this account, high grade bituminous coals have been almost universally employed.

It is our opinion, however, that the carbonization of Saskatchewan lignites must be considered from quite another angle. Here the main consideration is the production of the largest quantity economically possible of the best residue, while by-products are of relatively little importance. The yield of gas, tar oils, pitch, ammonia liquor, etc., is small in comparison with that obtained from higher-grade coals, and the character of some of these is so radically different from that of the staple kinds that their commercial value must be regarded as problematical. It is also to be borne in mind that the proposed carbonizing plant will be located far from any important centre of the chemical trade. This is another argument in favour of not devoting much attention to the utilization of the by-products, — at least, until the production of fuel shall have become well established.

We investigated the Smith "Carbocoal", Greene-Laucks, Thomas, and Marshall processes, those of the General By-product Gas & Reduction Co., and of the Oil & Carbon Products Co., Ltd., and also those employed by Dr. Bredlik, by Professor Parr and Dr. Layng at the University of Illinois, and by Professor Babcock at the University of North Dakota. A short description of each process is given in the following paragraphs.

While there is no apparent reason why a retort designed for by-product production from bituminous coals should not be adaptable to lignites, we believe that a simpler and cheaper apparatus can be developed for use with these non-coking coals.

To proceed now to a description of the processes we have investigated, we will take up each one in detail.

SMITH "CARBOCOAL" PROCESS.

This is the invention of Mr. C. H. Smith, and is controlled by the International Coal Products Corporation, a concern financed by Blair & Co., of New York, N.Y. These interests have erected a large plant at Irvington, N.J., and have been carrying on development work there for some time.

Briefly, in this process, raw coal is passed through horizontal retorts by means of a pair of screw conveyors (see Fig. 55). Here it is heated to a low temperature for about an hour, coming out at the discharge end, partly freed of its volatile matter, as so-called "semi-coke". This "semi-coke" is pulverized, mixed with coal tar pitch (obtained by distillation of the tar from both preliminary and final carbonizing) as a binder, and briquetted. The briquettes are then subjected to a heat treatment at a high temperature for about 4 hours in inclined retorts, thus driving off the remaining volatile matter and coking the pitch binder, so that the final product is a hard, dense briquette resembling gas coke.

The only portion of this process which is of particular interest for the moment is the preliminary carbonization. The present retorts are of cast-iron, shaped as shown in the plate, and lined with carborundum plates. New retorts which are being installed will be of "calorized iron". Each is provided with two horizontal shafts, carrying helical blades which agitate and advance the charge of coal. Feeding is accomplished by an automatic screw-conveyor device, the speed of which may be varied, and the "semi-coke" is withdrawn at the opposite end of the retort into a cast-iron cooling chamber.

Heat is furnished by gas burners arranged along the sides of the retort. There are a large number of these, hence the quantity of heat supplied and its distribution throughout the length of the retort may be closely regulated. The air required by the burners is passed through a preheater under the retorts, and thus some economy is effected.

Practically all the work done so far by the International Coal Products Corporation has been on coking coals, for which their retort is well adapted. Saskatchewan lignites have no tendency to coke when carbonized, however, and there is no means of telling how well and cheaply the Smith process will treat these. In order to get some positive information on this point, the Lignite Utilization Board has supplied the International Coal Products Corporation with a sample of lignite from the Souris field, to be tried out in a small experimental retort in the latter's laboratory. The results of this test have not yet come to hand.

GREENE-LAUCKS PROCESS.

The owners of the United States rights to the Greene-Laucks process are the Denver Coal By-product Co., of Denver, Colo., and their experimental plant is located in that city on the property formerly belonging to the American Coal Reduction Co.

The sketch of Fig. 56 shows diagrammatically the arrangement of a Greene-Laucks retort and its auxiliary apparatus.

This process uses a vertical cast-iron retort 12″ in diameter and about 12′0″ long, to which is added a further 4′0″ in length at the bottom as a cooling section. Carbonizing takes place under a high vacuum. Coal is fed in at the top, and the residue removed at the bottom, through rotating valves arranged to prevent the admission of air. The charge, in the form of a hollow cylinder, about 2½″ thick, is forced downward through the retort by a screw conveyor having a hollow shaft which serves as a gas offtake.

By means of an ingenious interlocking device, any retort which loses its vacuum is cut out of service at once, without affecting the others in the bench.

There are helical ribs cast on the outside of the retorts which, with the brick setting, form a spiral flue.

Heat from a combustion chamber serving four retorts is admitted to this flue by means of appropriate openings, and the additional heat needed is secured from independent gas burners in the flue itself. A jacket around the cooling section at the bottom of the retort preheats the air supply.

Any desired temperature, within reasonable limits, may be secured by proper manipulation of the burners, and the time of passage through the retort is expected to be about 35 minutes with a normal temperature of about 1,200 deg. F. Under these conditions the capacity of a retort will be about 500 pounds of bituminous coal per hour. It is the belief of the promoters of this process that with Saskat-

chewan lignite these figures may be greatly exceeded. Although the high vacuum is claimed by the promoters of this process to be largely responsible for the unusual yield of by-products, the retorts might perhaps be adapted for use with lignites if simplified and cheapened by the omission of the vacuum feature.

We were favourably impressed with the very careful manner in which the mechanical details of the Greene-Laucks process appear to have been worked out. At the time of our visit to this plant, however, it had not as yet been operated, so that we could form no opinion as to its actual practicability. We considered it sufficiently promising to have 30 tons of lignite slack from the Estevan Coal, Brick & Power Co.'s mine at Shand, Sask., forwarded to the Denver Coal By-products Co. for experimental purposes. No results have as yet been forthcoming, however.

Thomas Process.

The Thomas process, though originally designed for the carbonizing of coal, has been more fully tried out in the manufacture of wood charcoal. It is controlled by McPherson & Fullerton Bros., Vancouver, B.C., who have an experimental plant at Nanaimo, B.C.

Gas is used for transferring heat into the charge in this process, as may be noted by reference to Fig. 57. The gas given off in carbonizing the charge is passed through condensers, scrubbers, etc., to remove the moisture and vapourized by-products, and is then heated in an apparatus resembling a water-tube boiler. From this heater the hot gas is passed back into the retort containing the charge, there to part with its heat and pick up another load of moisture and vapours. There is, of course, an excess of gas produced in the process, which may be used to supply a part or all of the heat required for carbonizing.

While we did not visit the experimental plant itself, we were shown drawings of it, and it was carefully described to us. It is apparently of a makeshift character, the retort, for example, being the shell of an old vertical boiler.

Since this method of carbonizing was suggested to us by a number of different competent authorities, notably by some of the officials of the U.S. Bureau of Mines, we took particular interest in the Thomas process. It appears to us that the promoters have yet a good deal of development work ahead of them before their process can be said to be commercially successful, especially as applied to coals.

It will be noted that the gas is alternately heated and cooled, and, as gas has a very low heat capacity, that a large volume requires to be circulated to provide the necessary heat in the retort. Very efficient economizers must be provided to avoid prohibitive waste in the heat exchanges, and some system must be devised whereby the necessary volume of gas can be circulated through the mass of coal to be heated without undue work being done, if this process is to be adapted to the treatment of lignite.

Marshall Process.

This process is controlled by Mr. Denis Campbell, of Vancouver, B.C., who has an experimental plant at Port Mann, B.C. This plant proved to consist of a small bee hive oven arranged with openings in the floor for down draft, a condenser consisting of a line of steel pipe, and certain auxiliary apparatus. It had not been in operation for some time.

No experiments have ever been undertaken in this oven with lignite, but fair results were apparently obtained on coking coals, judging from the samples of coke which we found lying about the plant. A high yield of marketable by-products is claimed.

Similar ovens were tried at Hebron and Minot, N.D., some years ago. These were operated on North Dakota lignites and were a total failure. The product was composed of well-carbonized material, ash, and lignite which was totally unchanged chemically, but which had acquired much additional moisture during its stay in the ovens. These various products were so intimately mixed that any commercial use of the output was utterly impossible.

General By-Product Gas & Reduction Co.'s Process.

This concern is a subsidiary of Vielé, Blackwell & Buck, Consulting Engineers, New York, N.Y. Strictly speaking, they have never done much along the lines of carbonization, but have devoted their energies to the development of a continuous gas producer. The only one of these machines in operation at present is installed at the plant of the New Jersey Zinc Co., Palmerton, Pa. After talking with the company's engineers in New York, we concluded that their apparatus did not hold out much promise of being adaptable to our needs, and we did not, therefore, visit Palmerton.

Their gas producers, (see Fig. 58), consists of a rotating horizontal cylinder, slightly inclined, and with an enlargement at the lower end. It is supported on tires and carrying wheels, and revolved like a dryer. The enlarged end is provided with tuyeres, equipped with valves so that the air supply is turned on only when the tuyeres have passed below the level of the fuel bed, and is cut off as soon as they are above it, during the rotation of the producer. There is a continuous feeding device at the higher end, and a similar arrangement for ash removal at the lower end.

This machine is claimed to be very successful, operating on practically any low-grade fuel, and producing a gas of good calorific value. It is said that the ash agglomerates into balls, containing practically no combustible.

The engineers of this company believe that by a proper control of the air supply, only the volatile materials in a coal might be burned, allowing the carbon and ash to be withdrawn together. Hence the machine would act like a carbonizer, and might be called a "continuous rotary bee hive oven", for lack of a better term.

They have done only a little experimental work along these lines, however, and are not at all sure of the correctness of their position. Possibly it might work very well in this manner, when using a dry coal, but with raw lignite, the moisture given off would certainly combine with some of the carbon, decreasing the yield and value of the residue. Drying the lignite would probably do away with some of this trouble. The results of the one test made in this way indicated complete failure.

PROCESS OF THE OIL & CARBON PRODUCT CO. LTD.

This concern has been engaged for some time in experimental work on the distillation of oil shales and has recently turned its attention to coals.

The retort which they use, the invention of W. W. White, is a modification of the well-known Del Monte retort, and is shown in Fig. 59. The coal, which is fed from a hopper at the left, is carried by a screw conveyor through zones of increasing temperature, and discharged at the right. Multiple gas offtakes are provided.

This company is only nominally represented in the United States and Canada, and we were quite unable to secure any technical information as to their process from their agent on this side of the Atlantic.

BREDLIK'S CARBONIZER.

Dr. V. Bredlik, of the Gas & Coke Oven Corporation of America, has designed a vertical carbonizer very similar to the well-known Rollè type. Fig. 60 shows the general details of its construction.

WORK OF PROF. PARR AND DR. LAYNG.

Owing to the fact that much of the information given us by these gentlemen was highly confidential, we are not at liberty to disclose all the data we have regarding their process. It may be said, however, that they are attempting to actually coke non-coking coals by special methods which they have developed, and that enough has already been done by them along these lines to warrant anticipations of ultimate success. Some samples of Saskatchewan lignites have now been supplied them by the Board, with which they purpose to experiment.

WORK OF PROF. E. J. BABCOCK.

At the Mining Experiment Station of the University of North Dakota, Hebron, N.D., Prof. E. J. Babcock has been studying the problem of carbonizing lignite for some years. During this time, he has tried and abandoned many types of carbonizers. At present, he is using a combined vertical and inclined retort (as shown by Fig. 61), externally heated, which he claims is quite successful.

As described by him to us, this apparatus consists of a vertical shaft about 6′0″ high and 20″ x 30″ in cross-section. This is connected at the bottom to the upper end of an inclined retort about 10′0″ long and also about 20″ x 30″ in section. Baffle plates hang from the roof of the inclined retort, and there are gas offtakes along its length. The whole device is built of fire brick and provided with flues in the walls and bottom for gas firing.

Pulverized raw lignite is filled in at the top of the vertical shaft. By the time it has passed down the full length of this shaft, it has lost practically all its moisture, and the true carbonizing is done in the inclined portion. Flow through the retort takes place by gravity. A certain amount of stirring is produced as the charge slips under the hanging baffles. The time of carbonizing is regulated by the speed with which the carbonized residue is removed from the water seal at the lower end of the inclined portion of the retort.

This apparatus apparently gives a fairly satisfactory residue. The output is saturated with water from the seal, which is an objection. The gas yield is high, — so high that it seems certain that some of the moisture from the raw lignite must pass through the hot charge, producing a considerable amount of water gas, and reducing the calorific value of the residue.

MISCELLANEOUS.

In Montreal, New York, Chicago and Detroit, we met and interviewed many engineers connected with the coal gas industry, thinking that from them we might secure information which would be of value to us. In this hope, we must confess, we were largely disappointed. We did, of course, profit by these interviews, but in general we found that they could tell us little we did not already know. None of them had had any experience with lignites of any sort.

APPENDIX B. OF MAIN APPENDIX 16

GENERAL DESCRIPTION OF BRIQUETTING PLANTS INSPECTED.

Previous to proceeding to submit some notes regarding the various briquetting plants inspected by us, we wish to call your attention to Fig. 62. This is a composite flow sheet of a typical briquetting plant, using either pulverized (hard pitch) or melted (soft pitch) binder. The full lines indicate the path of the materials through a hard pitch plant, the dot-and-dash lines refer to a soft pitch plant. Certain apparatus which is occasionally, but not generally, installed is shown in dotted lines. A little study of this diagram may perhaps serve to make clearer the descriptive matter which follows.

The following operating plants were visited on our trip:—(See Fig. 7 and Plate 1).
Fuel Briquet Co., Trenton, N. J.
International Coal Products Corporation, Irvington, N. J.
American Briquet Co., Philadelphia, Pa.
Lehigh Coal & Navigation Co., Lansford, Pa.
Scranton Anthracite Briquet Co., Dickson City, Pa.
Gamble Fuel Briquet Co., Harrisburg, Pa.
Virginia Navigation Coal Co., Norfolk, Va.
Delparen Briquet Co., Parrott, Va.
Standard Briquet Fuel Co., Kansas City, Mo.
Pacific Coast Coal Co., Renton, Wash.
Bankhead Collieries, Ltd., Bankhead, Alta.
Stott Briquet Co., Superior, Wis.
Berwind Fuel Co., Superior, Wis.

A short description of each, accompanied by some notes, the results of our observations, is given in the paragraphs below.

KEY TO FIG. 62

1. Track hopper.
2. Crusher.
3. Elevator.
4. Coal storage.
5. Dryer.
6. Dryer furnace.
7. Elevator.
8. Dry coal storage.
9. Coal feeder.
10. Pulverizer.
11. Mixers.
12. Edge runner.
12a. Fluxer.
13. Press.
14. Screen.
15. Cooling table.
16. Briquette storage.
17. Screen.
18. Cars.
19. Boiler.
20. Hard pitch storage.
21. Elevator.
22. Hard pitch cracker.
23. Elevator.
24. Hard pitch pulverizer.
25. Pulverized pitch feeder.
26. Soft pitch storage tank.
27. Pump.
28. Soft pitch heating tank.
29. Pump.
30. Heat adjustment.

FUEL BRIQUET CO., TRENTON, N. J.

This concern was organized about 18 months ago by the Pagenstecher paper interests of New York, principally for the purpose of affording an outlet for the sulphite pitch manufactured at their pulp mills. The principal supply of this material comes from their mill at Palmer, N. Y., and is received as a 50% solution in tank cars, from which it is run into concrete storage tanks. The pitch is about 1.3, specific gravity.

Wet anthracite culm is the raw material briquetted. This is bought in the open market, and at the time of our visit, was being obtained from the Lykens Valley (Pa.) field.

After being passed through a Ruggles-Coles dryer, which is fired with broken briquettes and other waste the culm is elevated to storage. From the storage bins, which have a capacity of about 50 tons, the dried culm is passed to the mixer, which is of the paddle type. Here hot sulphite pitch (150° — 175°F melting point) is added so as to give a mixing ratio * of about 11. The partially mixed material is then passed to an edge runner for further mastication. In passing, it is proper to note that the edge runner, which was made by the General Briquet Co., New York, N. Y., is far too light for the service, so that it has been necessary to reinforce the frame. The arrangements for fixing the angle of the plows are also faulty, as those cannot be firmly held in proper position. From the edge runner, a screw conveyor, in which some further mixing takes place, delivers the material to an elevator, discharging into the fluxer. This apparatus is of the cylindrical vertical type, having blades mounted on the rotating shaft, which pass between similar blades mounted on the shell, the object being to cut, squeeze and mix the material in the most intimate possible manner.

Immediately under the fluxer are two roll presses making egg-shaped briquettes, and having a combined capacity of from 8 to 10 tons per hour. These are of Belgian manufacture, and do not give entire satisfaction. The shape of the briquettes involves a considerable percentage of waste space on the faces of the rolls, and hence, a comparatively large quantity of fines. There is also a tendency for the lower end of each briquette to be somewhat split as it somes from the press, due to the pinching action of the rolls. This, however, is not an important matter.

From the presses, the briquettes are conveyed to a point about one-fifth its length from one end of a cooling belt, which travels about 12 feet per minute. By driving the belt in one direction, the briquettes may be loaded directly into cars, by driving it in the other direction they pass up an incline to a wooden storage bin. Some tests carried out in our presence proved that it would not be practicable to load cars directly from the cooling belt, as the briquettes had not hardened sufficiently to stand the drop from the belt to the car floor in the 5 or 6 minutes during which they had then been exposed to the atmosphere. They were, however, sufficiently hard by the time they had arrived at the storage bin to stand dropping into the bins through a Humphrey ladder, but at this point they had been cooled for from 20 to 25 minutes.

As straight sulphite pitch is the binder used, the briquettes are not waterproof, and consequently must be protected from the elements. At present, the company's entire output is being sold locally, with truck delivery, and care is taken that the briquettes are kept dry. A considerable portion of the present business is represented by the bag trade. Selling prices are $10 per ton, delivered in bulk, or $1·8 per ton in 50-lb. paper bags.

In order to waterproof the briquettes, the company is erecting an oven where they will be given a heat treatment lasting about one hour and fifteen minutes. One hour of this time will be spent in passing through a preliminary oven in which the temperature will range from 300° to 500°F, and 15 minutes will be required to pass through the final oven, where the temperature is expected to reach 650° or 750°F. In its essential details, the oven consists of a long steel-plate conveyor, passing backward and forward within a steel-plate setting insulated with asbestos, for the preliminary oven, and through a brick chamber for the final oven. The final oven is heated by indirect heat from a special furnace, and the preliminary oven is directly heated by the flue gases from the final oven. Numerous pyrometer openings and cold air inlets are provided, so that the temperature within the oven may be accurately controlled.

The behaviour of these non-waterproof briquettes in the fire, whether burning at a high rate of combustion, as in the dryer furnace, or at a low rate as in a heating stove, appears to be good. There is little apparent annoyance from smoke, no offensive odor, and the briquettes hold their shape well and withstand poking until they are entirely consumed. The residue under the grates is a fine powdery ash, containing very little visible unburned combustible.

This plant, although practically a new one both in buildings and equipment, occupies the site of a former plant. The design was made, and the machinery, with the exception of the presses, supplied by the Malcolmson Briquet Engineering Co., Chicago, Ill. The plant was being operated at the time of our visit by an employee of the Malcolmson Co., Mr. D. C. Williamson. Mr. Williamson is not impressed with the virtues of sulphite pitch as a binder, saying that it is sticky and difficult to handle.

*The "mixing ratio" is the quantity of binder added to 100 parts of coal, see p. 72

No statement could be obtained from the company as to the capital outlay represented, nor as to the costs of manufacture. It is stated, however, that the total cost of the plant was not far from $250,000. They had no reliable cost figures, since at the time of our visit, operations had been going on for only about 6 weeks, and the heat treating oven was not yet ready for use. The power requirements of this plant, as taken from the rating plates of the various motors, are as follows:—

Dryers and fan	50 h.p.
Feeder, mixer and conveyor	25 h.p.
Edge runner	50 h.p.
Fluxer and two presses	60 h.p.
Two elevators	10 h.p.
Small conveyors and miscellaneous apparatus	15 h.p.

There is also one 75 h.p. boiler supplying steam for heating, etc.

This, the first plant to be visited, has been described at some length because most of the others which we inspected follow the same gereral arrangement, and because it is one of the newest, if not the newest, which we saw. It may, therefore, be safely assumed to represent advanced practise in the art of briquetting.

INTERNATIONAL COAL PRODUCTS CORPORATION, IRVINGTON, N. J.

This corporation is financed by Blair & Co., the New York banking house, and is engaged in developing the carbonizing and briquetting processes of Mr. C. H. Smith.

The plant is an extensive one, though only experimental, and represents a total investment, so we were told, of approximately $750,000. In addition to the carbonizing and briquetting equipment proper, there is extensive apparatus for tar distillation, etc., and numerous and well-equipped laboratories. As these latter do not concern us directly, we will omit further mention of them.

The preliminary carbonization of the Smith "Carbocoal" process has been described in Appendix A on page 143.

The "semi-coke" from the preliminary carbonization is pulverized, and either hard or soft pitch added as a binder. 172°F melting point is preferred, which is obtained from the tar from the carbonization and heat treatment processes. A mixing ratio of from 9 to 11 is used.

There is nothing particularly novel as far as the briquetting apparatus is concerned. There is a Komarek press (see Plate 2) which turns out barrel-shaped briquettes weighing 2 ounces.

The briquettes are subjected to a secondary heat treatment in inclined gas-fired retorts at temperatures approximating 1800°F. This secondary distillation drives off from the briquettes whatever volatiles may have been left in the "semi-coke", and also cokes the pitch binder. The result is a substance very much resembling coke, low in volatiles and therefore practically smokeless. Considerable control over the quality of the product is obtained by varying the final heat treatment.

While one of the objectives of the Smith process is the production of a smokeless fuel, the company's expectation is that the income from the sale of by-products will be sufficient to pay operating charges, leaving the revenue from the sale of briquettes as profit.

Although this plant is a large one, being designed to treat 100 tons of raw coal per day, yet it is distinctly experimental, and for that reason there is no reliable information regarding the financial aspects of the process. Its promoters are sanguine of its success, and at the time of our visit, were arranging to erect a large plant at Clinchfield, Va., the capital for which was to be advanced to them by the United States Government.

AMERICAN BRIQUET COMPANY, PHILADELPHIA, PA.

This company has been operating a small experimental plant using "Hite" binder. This work was so successful that they closed down their Philadelphia plant early in 1918, in order to proceed with the erection of a much larger plant on the property of the Susquehanna Coal Co., at Lykens, Pa.

The "Hite" binder is an emulsion composed of starch, water and some tarry or asphaltic material. The starch paste is expected to provide the binding properties, and the bitumen is supposed to act mainly as a waterproofing agent. In practice, one part of starch is added to twelve parts of hot water, and the mixture steam cooked until the result is a compound not unlike paperhangers' paste. To this pasty mass is then added two parts of melted bituminous material. During the addition of the latter the whole mass must be violently agitated. The final compound is a brownish-black, sticky emulsion which is quite fluid when hot. The briquetting apparatus which the company had installed in its experimental plant is rather crude, and consists of the usual mixers, a roll press making pillow-shaped briquettes (see Plate I), etc. About 8.7 parts of emulsion per 100 parts of coal are used.

The briquettes on leaving the press contain the water which was used in preparing the binder. This water must be removed if a satisfactory briquette is to be produced. The briquettes are therefore dried in an oven very similar to the one described as having been inspected at the plant of the Fuel Briquet Co. The maximum temperature of the air in this drying oven is not over 500°F, and the temperature of the briquettes as they leave it is about 100°F. It is claimed that 20 minutes is sufficient time for proper treatment, but in the new plant it is proposed to give the briquettes a drying period of 40 minutes, to be followed by a cooling period of 20 minutes.

Among the advantages of the "Hite" binder are :—

1. A large part of it is water, an inexpensive ingredient.
2. Low grade flour might perhaps be substituted for starch, and this may possibly be easily and cheaply obtained in the West.
3. The waterproofing bitumen may perhaps be procured from the lignite tar carbonization.
4. This binder is claimed to produce a practically smokeless briquette, a very desirable feature.
5. Although a final heat treatment is required, the necessary temperature is low, and the process is one already well-developed commercially.

If the "Hite" binder will bear out in practice the claims made for it by its promoters, it offers distinct advantages in the case of a briquetting plant located far away from centres of supply, as the Board's proposed plant will be.

The manager of the next plant visited, who had himself experimented with the "Hite" binder, stated that simple drying would not give a waterproof briquette, but that this result could be accomplished by baking the briquettes at a temperature of not less than 380°F.

LEHIGH COAL & NAVIGATION CO., LANSFORD, PA.

This concern has a very successful plant using the breaker dust from its own anthracite mines. During 1918, its output was in the vicinity of 85,000 tons of 3-ounce eggshaped briquettes.

The arrangement of the plant leaves much to be desired. The buildings are old, dark and dirty, and much of the equipment far from modern. It enjoys, however, careful supervision, as well as the numerous advantages which accrue to it from the fact that it is a unit in a large industrial organization.

The anthracite culm is dried to about 2% moisture, and then passed to the mixer, where the binder, (5.3. parts per 100 of coal), an oil asphalt (148°F melting point), is added. Following the mixer is an edge runner, and then a fluxer of the vertical type, where sufficient steam at 80 pounds pressure is injected into the mass to raise its temperature to 140°F.

The two presses were built by the Traylor Engineering Co., Allentown, Pa., and are of the usual roll type. Their only notable feature is the rather unusual diameter of the rolls, — about 40 inches.

From the presses, the briquettes pass to the storage bins or directly to the cars. The travel from press to point of loading is short, and in order to cool the briquettes down sufficiently, water sprays are freely used.

There are one or two features concerning this plant worthy of particular note. The method of handling the binder is interesting. The asphalt is melted in large steam-heated tanks and pumped from these to a small tank directly over the mixer. From this small tank there is a return back to the melting tanks so that the asphalt is always in circulation. In order to keep the binder sufficiently fluid, all asphalt pipes are paralleled with live steam pipes, and both are wrapped in the same insulating covering.

Owing to the very dusty atmosphere, the company has found it advantageous to equip all its workmen inside the plant with respirators. Some years age, a system of bag filters was installed for the purpose of reducing the dust nuisance, but it was not successful and was abandoned.

The Lehigh Coal & Navigation Co., has at present under construction an entirely new plant on a nearby site, which will have a capacity of 1,000 tons of briquettes per day. As far as equipment is concerned, it will follow the designs which the present plant has shown to be successful, except that no edge runner will be used. Especial care is being exercised to do away as far as possible with the dust nuisance and to provide abundant natural illumination.

SCRANTON ANTHRACITE BRIQUET CO., DICKSON CITY, PA.

This is an old plant, adjacent to an anthracite breaker, and is receiving culm washed out of the coal. This comes to the plant in a stream of water, is settled out in a concrete basin and removed by a bucket elevator which deposits it in an overhead bin.

Drying is by direct heat, and the dried culm passes through two paddle mixers, where coal tar pitch (190-195°F, melting point) is added. The mixing ratio is about 10. There is no fluxer, and the hot material from the mixers is cooled to a temperature of approximately 150°F by falling through a current of air just before it goes to the press.

The presses were built by the Vulcan Iron Works, of Wilkes-Barre, Pa., according to the designs of Mr. J. F. Lovejoy, manager of the briquet company, and produce egg-shaped briquettes, weighing approximately 2½ ounces. Cooling of the briquettes is effected by discharging them into a tank of water from which they are removed by a scraper conveyor.

On the whole, the plant is old, poorly arranged, and must be inefficient. Mr. Lovejoy believes coal tar pitch to be the most satisfactory binder, although he admits it to be smoky and to produce disagreeable fumes, both of which objections he thinks can be overcome by intelligent firing. He objects to oil pitch, claiming that it does not coke, and that it softens objectionably in heat. He is opposed to the use of any binder containing water, or involving a final heat treatment of the briquette for the purpose of waterproofing, as he thinks that such heat treatment must necessarily produce a porous briquette. In his own plant, neither steam nor water is added to the mixture at any point.

GAMBLE FUEL BRIQUET CO., HARRISBURG, PA.

This company is briquetting anthracite slack, part of which is received by rail from the mines, and part of which is dredged from the Susquehanna River.

The raw material is passed through a steam-heated dryer, then pulverized so that it will all pass a 50-mesh screen, but much of it if far finer than this. A second steam dryer raises the temperature of the pulverized material to about 220°F.

Paddle mixers are used, and sulphite pitch is added in the first one, (mixing ratio about 3.6). A few feet further along, approximately the same quantity of oil pitch is added. If both binders are added at the same point, the water in the sulphite pitch causes frothing. The temperature of the binders is about 200°F.

There is no fluxer; 1½ ounce pillow-shaped briquettes are made in a roll press. Formerly this company used a straight sulphite pitch binder with a subsequent heat treatment for waterproofing, but after the expenditure of considerable time and money, decided that this process was not commercially practicable, and adopted the procedure which they now follow.

Dr. B. E. Gamble, the prime mover in this concern, thinks that the essential points of success in briquetting are as follows:—

1. Thorough drying. His steam dryers are not satisfactory.

2. Thorough pulverizing. While the finer powder requires more binder, it produces a better-looking and stronger briquette.

3. Thorough mixing. He has a high opinion of paddle mixers. Does not think the edge runner and similar devices are worth their cost.

4. Correct pressure in the press. He believes that his own press exerts about 1,400 pounds per square inch on the briquettes, but admits that he has no definite means of knowing what the pressure is.

As a further result of his experience, he believes the most economical layout is one in which all machinery is on the same level, the necessary elevators and conveyors being provided. He also emphasizes the great advantages of abundant light and the absence of dust.

VIRGINIA NAVIGATION COAL CO., NORFOLK, VA.

This company proposes to ship Pocahontas coal from the mines to their plant, which is about 10 miles from Norfolk, Va., and to screen it there, selling the lump and briquetting the slack. They had arranged to export their briquettes to South America through W. R. Grace & Co., and for that reason had adopted 16 ounces as the best size, this being what is demanded by the export trade.

Their plant, which is modern in every way and is probably the most conveniently arranged and best constructed one which we saw, was ready for operation only after the establishment of the United States Fuel Administration. The regulations of the Administration have prevented the company from doing any export business, and, as there is little or no market for their large briquettes on this continent, the plant has never been put into regular operation.

There is an elaborate equipment for unloading and screening run-of-mine coal as received, and much storage is also provided for it at this point. The screenings are dried in Ruggles-Coles dryers.

The mixing ratio so far employed varies between 6.4. and 7.5. The hard pitch (193°F melting point) is added to the coal as it leaves the dryers and the mixture is then passed through a pulverizer. Considerable difficulty has been experienced at this point, owing to the tendency of the pulverizer to gum. At the time of our visit, this trouble had not been entirely overcome. The previously mixed material is still further mixed in a paddle mixer, and then passes through a three-story horizontal fluxer of the Malcolmson Briquet Engineering Co.'s standard design. This apparatus is followed by a reheater, using flue gases from the boiler.

A Rutledge press (see Plate 2) is installed, which as yet has not been entirely successful in its operation. The buildings and equipment are first-class in every respect, and were designed by the Malcolmson Briquet Engineering Co., Chicago, Ill. Every labor-saving device applicable has been employed. The total cost is stated to have been approximately $600,000, which includes building accommodation for another briquetting unit similar to the one already installed. Based on 24-hour operation, the capacity of the plant will then be about 2,000 tons per day.

DELPAREN BRIQUET CO., PARROTT, VA.

This plant is located adjacent to the mine of the Pulaski Anthracite Co., and is controlled by the same interests. The material being handled is so-called "Virginia anthracite", which perhaps might more properly be classed as a semi-anthracite.

The screenings from the breaker are first dried in steam dryers, which are stated to be satisfactory. It may be noted, however, that the screenings are never exposed to the weather, and that the mine itself is very dry, so that the moisture content of the raw coal is presumably low.

Hard oil pitch is used as a binder, pulverized before being added to the coal. At the time of our visit, the pitch being used was a job lot, whose melting point varied from 140°F. to 222°F. It had been in storage for a considerable period, and was originally shipped in gunny sacks, from which it could not be separated. The result was that the company has found it necessary to employ a number of men to pick out the threads, etc., from the binder, at various points along the line, before it is added to the coal, and even then a considerable quantity of this foreign matter finds its way through the mixers and presses.

There are four paddle mixers, the first two of which are steam-jacketed, and the last two without steam jackets. The binder is added to the coal at the outgoing end of the first mixer. At the present time, a mixing ratio of 11.1 is being used, which is admittedly excessive, but which, it is claimed cannot be reduced owing to the variable quality of the binder itself. Steam is introduced into the mixture during its passage through the last two mixers. Enough is added so that moisture is actually squeezed out of the mixture by the press.

The press itself is of the usual roll type, making 2½ounce pillow-shaped briquettes, and delivers to a cooling table on which the briquettes remain for about 20 minutes.

The present sales price is $6.00 per ton, f.o.b. the plant, and the bulk of the product is disposed of in Norfolk, although occasional shipments are made as far north as Michigan. The briquettes are commonly used throughout the village, and appear to give satisfaction.

This plant was designed and constructed by the Mashek Engineering Co., New York, N.Y.

STANDARD BRIQUET FUEL CO., KANSAS CITY, MO.

This company's plant is substantially the same as that of the Virginia Navigation Coal Co., though much older and consequently not in as good condition. It was built by the Malcolmson Briquet Engineering Co., Chicago, Ill.

The raw material is slack from the Arkansas semi-anthracite mines. The binder is oil pitch, and the mixing ratio about 7.5.

There are no particular points of novelty to mention here, but it is interesting to note the superintendent's remarks regarding his Rutledge press, (see Plate 2), the repair costs on which he stated to have been less than $100 for four years. He admits, however, that a large quantity of oil is required, approximately one barrel per day.

The briquettes which weigh 11 ounces, find a ready sale in Kansas City, and the prices are as follows:—

F.o.b. cars, plant	$ 8.00 per ton.
F.o.b. trucks, plant	8.50 " "
Delivered to retailers	11.35 " "
Delivered to consumers	16.35 " "

The current local price for the best Arkansas semi-anthracite lump at the time of our visit was $15.60, delivered to consumer.

PACIFIC COAST COAL CO., RENTON, WASH.

This is a subsidiary of the Pacific Coast Co., a concern which has large mining and other interests in the Puget Sound territory. Their briquetting plant is conveniently located at the junction of the railway lines from three of their principal mines.

The raw material is a mixture of coals, the proportions being determined principally by the proportion in which slack is produced by three mines contributing. At present, the mixture consists of 50% lignite, so-called, from Coal Creek, 30% free-burning bituminous coal from the Black Diamond mine and 20% coking bituminous coal from South Prairie.

These coals are first mixed, then dried in Ruggles-Coles dryers, and then pulverized. The binder consists of oil pitch (mixing ratio 7.5) which is melted and added to the coal in the usual way in a paddle mixer. From this mixer, the hot material passes through a horizontal three-story fluxer, where a certain amount of steam is added, and then through two more paddle mixers in which most of the moisture evaporates.

A Rutledge press is used, making 10-ounce briquettes. The press plungers are hard bronze alloy, and the dies are lined with bushings of nickel-steel. It is estimated that one set of dies and plungers will produce 20,000 to 25,000 tons of briquettes. The company is well satisfied with the operation of the press, which, until recently, has been running 16 hours a day.

After leaving the press, the briquettes are cooled for about 15 minutes under water sprays on a travelling belt, and then go either to the cars or the storage pile.

The present selling price is $6.45 per ton, f.o.b. cars at the plant. The principal markets are in Seattle, Tacoma, Portland, Spokane and other points within a shipping radius of about 200 miles. From 6,000 to 8,000 tons were exported this season to Chile, and it is reported that they gave excellent satisfaction.

The plant was designed and built by the Malcolmson Briquet Engineering Co., Chicago, Ill.

BANKHEAD COLLIERIES, LTD., BANKHEAD, ALTA.

This plant has a capacity of 500 tons per 10-hour shift, and is utilizing screenings from the Bankhead Mine, adjacent to which it is located. The first unit was installed in 1907, and the second in 1909. Since commencing operations, the company has produced over 1,000,000 tons of briquettes. The following description applies to each unit.

There are no dryers as such, but the raw coal passes directly to six paddle mixers, having bodies of brick or concrete, the first two of which are heated externally by the gases of combustion from a special furnace. At the end of the third mixer, the binder, (coal tar pitch, 143°F melting point) is sprayed in with a steam jet. The mixing ratio is about 8.7. The specifications for binder call for not over 25% free carbon, and the melting point is determined by the cube test. The last three mixers are not heated, and serve merely to masticate the compound. The soft pitch is received and stored in tank cars.

Roll presses making 2½ ounce pillow-shaped briquettes are used. After leaving the presses, the briquettes spend about one hour on a series of cooling tables, and are then ready for shipment or storage.

The entire plant was designed and built by the Zwoyer Fuel Co., New York. N.Y. The layout leaves much to be desired, and the plant is dark and dirty. It has, however, a good record for efficiency, the repair charges having been low. For long periods at a time it has operated 24 hours per day and six days per week.

This concern is a subsidiary of the Canadian Pacific Railway Co., and is operated under the direction of Mr. Lewis Stockett, General Superintendent of Mines, Department of Natural Resources, with Mr. D. G. Wilson in immediate charge.

About one-third of the plant's output is sold to the railway company, and is used by them mixed with twice its weight of Canmore coal, as locomotive fuel. The balance is sold for domestic purposes, and a considerable quantity finds its way as far east as Winnipeg. The present selling price is $4.35 per ton, f.o.b. Bankhead.

STOTT BRIQUET CO., SUPERIOR, WIS.

This plant was designed and built by the Maskek Engineering Co., New York, N.Y., and is very similar to the one at Bankhead.

The raw material is a mixture of anthracite and Pocahontas dust from the docks at Superior. The proportions used vary from half and half to 35% anthracite and 65% Pocahontas, depending on the relative supply of the two materials.

There are no dryers, but the first four of the six mixers are direct heated as at Bankhead. Oil pitch binder (145° — 150°F melting point) is used, which is sprayed into the fourth mixer at a temperature of from 225° to 250°F. A mixing ratio of 7 is customary. A notable feature of this plant is the high speeds employed in the mixers, which are respectively 180, 160, 160, 160, 120 and 200 r.p.m.

Roll presses making 2½ ounce pillow-shaped briquettes are employed. These run at 11 r.p.m., 24 hours per day, and the life of a set of rolls is estimated at about 40,000 tons.

After cooling in the usual manner, the briquettes are shipped.

At the present time, the company is paying $3.50 per ton, plus freight, for anthracite dust, $6.50 per ton, plus freight for Pocahontas dust, and about $26.00 per ton for binder, delivered at the plant. The selling price of the briquettes is $8.50 per ton f.o.b. plant.

About 45 men are employed on three shifts, and wages run from 50 to 66¼ cents per hour. The company estimates that the binder costs them approximately $2.00 per ton of briquettes, and that labour amounts to 50 cents per ton. The power required is 160 h.p., which is supplied by large motors, group driving being employed. The power bill runs from $500 to $600 each month.

This company at one time tried coal tar pitch as a binder, but abandoned it on account of trouble with their men, who suffered from the dust and fumes from the pitch.

BERWIND FUEL CO., SUPERIOR, WIS.

This company is briquetting Pocahontas screenings which are delivered to the plant by an elaborate conveyor system from their own docks.

They have two complete briquetting units, one using melted oil pitch with a little coal tar pitch as a binder, and producing small briquettes, the other using hard coal tar pitch and producing large briquettes.

For both units, the raw coal is first dried in Ruggles-Coles dryers.

For the small briquettes, the dried coal next passes through a paddle mixer where the melted binder is added. The mixing ratios are about 6.5 oil pitch and 1.1 coal tar pitch. The oil pitch has a melting point of about 150°F. Both binders are added to the dried coal at the same time. The mixture is then passed through a horizontal three-story fluxer and two edge runners to the press.

The press, which produces cylindrical briquettes, is of the Komarek (see Plate 2) type. It is stated to be thoroughly satisfactory, though repair costs and upkeep have been high, and considerable skill is required to make it operate well.

The dry coal for the company's other unit is mixed with the pulverized hard pitch binder, (mixing ratio, 7.5), and passed through a pulverizer, thence through the usual mixers, etc., to a Rutledge press which produces 13-ounce briquettes. The repairs and upkeep of this press are stated to be slightly higher than the corresponding items for the Komarek, but it is said to require less care and skill in its operation. The Komarek press runs two 10-hour shifts, while the Rutledge press runs only one 10-hour shift. The actual operating, time in each case is about 8½ hours per shift, the balance being required for oiling, minor repairs, cleaning, etc.

Originally the company had two Rutledge presses, and their output was entirely of 13-ounce briquettts. It was found, however, that the market would not absorb the large briquettes readily, and consequenly they replaced one of the Rutledge presses with a Komarek.

This plant was designed by the Malcolmson Briquet Engineering Co., Chicago, Ill.

As a matter of interest and information, Plate I has been prepared. This shows the shape and relative size of the various styles of briquette which are now being commercially manufactured, or which have recently been on the market. The following table gives some details as to these briquettes.

Ref. no.	Company	Material	Binder	Wt Briquette, ozs.	Press
1	Pacific Coast Coal Co. Renton Wash.	50% raw lignite & 50% bituminous	Asphalt	10	Rutledge
2	Berwind Fuel Co. Superior, Wis.	Bituminous	Coal tar pitch	13	Rutledge
3	Standard Briquet Fuel Co. Kansas City, Mo.	Semi-anthracite	Asphalt	11	Rutledge
4	Virginia Navigation Coal Co. Norfolk, Va.	Bituminous	Coal tar pitch	16	Rutledge
+5	Johnson Fuel Co., Scranton, N.D.	Raw lignite	None	14	Fernholtz
●6	Colonial Coal Co., North Sydney, N.S.	Bituminous	Coal tar pitch	5	Roll.
+7	Am. Coal Reduction Co., Denver, Col.	Carbonized lignite		3	Roll.
8	Scranton Anthracite Briquet Co., Dickson City, Penn.	Anthracite	Coal tar pitch	2½	Roll.
9	Berwind Fuel Co., Superior, Wis.	Bituminous	Asphalt & coal tar pitch	2¼	Komarek
10	Int. Coal Products Corpn., Irvington N.J.	"Semi-coke"	Coal tar pitch	1¾	Komarek
11	Gamble Fuel Briquet Co., Harrisburg, Penn.	Anthracite	Sulphite pitch & asphalt	1½	Roll.
12	Fuel Briquet Co., Trenton, N.J.	Anthracite	Sulphite pitch	1	Roll.
*13	Am. Briquet Co., Philadelphia, Penn	Anthracite	"Hite"-starch & asphalt	2	Roll.

+Unsuccessful, plant closed ●Plant closed: change in market *Plant closed: larger plant building.

APPENDIX C OF MAIN APPENDIX 16

Memorandum on the Present Status of the Use of Pulverized Fuel.

There appear to be two schools among those who advocate the use of pulverized coal as a fuel. One advocates thorough drying and very fine grinding; the other believes that much drying is unnecessary and that sufficiently good results can be obtained with a much coarser powder than is held to be requisite by the first school.

It appears that the most successful plants where pulverized coal is used as a fuel for boilers, or for metallurgical operations, are those designed and built by engineers who adhere to the views of the first school. On the other hand, cement kilns, gypsum kettles and the like, are frequently fired with much cheaper apparatus supplied by the adherents of the second school. These plants have, in most cases, operated with a fair degree of success, but it is noteworthy that the only one of this type which we encountered on our trip was distinctly unsatisfactory, as will appear hereafter.

MILWAUKEE ELECTRIC RAILWAY & LIGHT CO., MILWAUKEE, WIS.

The first powdered coal plant which we saw in operation was that of the Oneida Street power house of the Milwaukee Electric Railway & Light Co. at Milwaukee, Wis. Here there are 2800 h.p. of Edgemoor water-tube boilers fired with equipment supplied by the Locomotive Pulverized Fuel Co., New York, N.Y. The raw coal being used at the time of our visit was screenings from the Illinois mines. This material is dried in a Ruggles-Coles dryer until it contains less than 1% moisture, and is then pulverized in Fuller-Lehigh mills.

The feeding apparatus is of the standard "Lopulco" design and consists essentially of a screw conveyor, driven by a variable-speed motor, which delivers the coal into an air blast. In this plant the furnace fronts have been extended about 5 ft., the grates removed, the bridge wall moved back, and the bottom of the old ash hopper taken out, so that the combustion chamber is probably about five times as large as when hand firing was practised. The coal jets enter the combustion chamber vertically through the roof of the extension and the flame does not extend down to the floor.

There is not sufficient air injected along with the powdered coal to provide for its complete combustion. It is, therefore, necessary to introduce a large quantity of excess air through openings provided for this purpose in the front and side walls of the furnace extensions.

Very little trouble has been experienced with the fire brick of which the combustion chamber is built, since the final arrangement of burners and walls was adopted. At first, however, no refractory material could be found which would withstand the intense heat of the flame, when this impinged directly upon it. By dint of repeated trials, and remodelling of the furnace, the present design was arrived at. This has been quite satisfactory.

Slagging has not been found objectionable. The slag which is deposited on the walls of the combustion chamber is kept sufficiently fluid by the heat, so that much runs down and collects in the bottom in a granulated form which is easily removed. A certain amount of fine dust is deposited on the lower two or three rows of boiler tubes. This is removed with a soot blower once or twice a day.

The drying and pulverizing equipment is not conveniently arranged, but it had to be installed in the space formerly occupied by the storage bins at the top of the building.

The company is pleased with this installation, and claims that it is remarkably efficient.

Ash Grove Portland Cement Co., Chanute, Kan.

While in Kansas City, Mo., we got into telephonic communication with Mr. W. P. Murphy, Chief Engineer, Ash Grove Portland Cement Co., Chanute, Kan. This concern has been using pulverized fuel in their boiler plant, but Mr. Murphy stated that they had not been operating for some time, on account of over-production in the cement industry. Their apparatus is entirely home-made, and there are no particularly noteworthy features with regard to it, according to his statement, We did not visit this plant.

Missouri, Kansas & Texas R. R., Parsons, Kan.

We were told by Mr. Maguire, of the Standard Fuel Briquet Co., Kansas City, Mo., that the plant of the M. K. & T. R. R. Co., at Parsons, Kan., employs Fuller-Lehigh apparatus. They have in the past burned some Arkansas lignite there, but at the present time were using a much better coal. As we had already visited a similar and more modern plant at Milwaukee, we did not think it necessary to spend the time required for a visit to Parsons.

Pacific Coast Coal Co., Seattle, Wash.

The Pacific Coast Coal Co., Seattle, Wash,. has taken up extensively the development of pulverized fuel. At the present time, the L. C. Smith Building, the New Richmond Hotel, the Broadway High School a natatorium, and the Western Avenue Station of the Puget Sound Traction & Light Co., are equipped with their apparatus.

Essentially, it is very much the same as that of the Locomotive Pulverized Fuel Co., though of considerably simpler design. The feeders consist of screw conveyors working in 3½ in. pipe, and the greater part of the equipment is composed of standard pipe and pipe fittings.

They use a very much larger volume of air than the Locomotive Pulverized Fuel Co. does, providing sufficient, mixed with the coal, to insure its proper combustion. A slight amount of clean air may be added to the air-and-coal mixture at the base of the nozzle, if required, but this is seldom necessary. Consequently, very little excess air is introduced through the front of the boiler. The nozzle consists merely of a length of pipe, and upon it is mounted a steam pipe, from which a small fan-shaped jet of steam impinges at an angle of about 45°, on the top of the mixture of air and coal at the nozzle outlet. As the nozzle is horizontal and inserted through the firing doors, this steam jet tends to blow the flame down and away from the boiler tubes.

This company reports absolutely no trouble with slagging or melting down of the furnace walls in any of their installations. The small quantity of flue dust which settles on the boiler tubes is blown out at regular intervals. No changes are required in the furnaces,except the removal of the grates and bridge walls.

The speed of the feeders is controlled either by means of a friction drive, or by equipping them with variable speed motors. The later installations have motors, but the company's engineer prefers the friction drive, as it is simpler and gives a wider range of speed.

Powdered coal is delivered to the consumers from the company's drying and pulverizing plant at Renton, Wash., except in the case of the Western Avenue Station, (about 4200 h.p.), where the drying and pulverizing is done in the building.

The coal which this company uses is a mixture of 50% Coal Creek (lignite), 30% Black Diamond (free-burning bituminous) and 20% South Prairie (coking bituminous). The company does not claim any special virtue for this mixture. It merely happens to be the proportions in which the slack from their mines reaches their briquetting plant, where the drying and pulverizing is done. They prefer Raymond mills, while the Western Avenue plant is equipped with Fuller-Lehigh dryers and mills. They are quite emphatic in their preference for the former, stating that any mill which depends upon screens for separation is sure to be troublesome. The air separation of the Raymond system, on the other hand, is claimed to operate perfectly.

Manitoba Gypsum Co., Ltd., Winnipeg, Man.

At Winnipeg we saw a battery of "Aero" pulverizers firing a rotary kiln and gypsum kettles at the plant of the Manitoba Gypsum Co., Ltd. The superintendent of this company stated to us that they were about to scrap the entire equipment, as they could not see that it had any advantages over hand firing.

At this plant they endeavoured to burn some of the lignite carbonized by Mr. S. M. Darling at Estevan, Sask., but without success. They also endeavoured to burn raw Souris lignite, and this effort was also unsuccessful, although more encouraging. It must be remembered, however, that with this system, the coal is not dried, nor is it finely pulverized, and with a different sort of equipment, quite different results might reasonably be expected.

Powdered Coal Engineering & Equipment Co., Chicago, Ill.

The Powdered Coal Engineering & Equipment Co., Chicago, Ill., have a very complete experimental plant. This concern, which is exploiting the "Pruden" system, has just placed on the market a self-contained unit designed to burn from 10 to 60 lbs. of coal per hour. This apparatus consists of a motor-driven fan and a motor-driven feeder. The motor speeds are controlled by suitably shaped cams so that the pro-

portions of the mixture of coal and air are always kept constant, no matter what quantity is being burned. These cams are in turn controlled by a thermostat, which may be placed in the room to be heated, or in a hot water main or steam pipe.

The "Pruden" system differs from others in producing a mixture very rich in coal dust, and then diluting this near the burner with sufficient air to provide the amount required for perfect combustion. This concern is very insistent that the ordinary methods of mixing coal and air are faulty in not being sufficiently thorough.

London Rolling Mills Co., Ltd., London, Ont.

The Bonnott Co., Canton, O., installed a pulverized coal system for furnace heating for the London Rolling Mills Co., Ltd., London, Ont.

By this system the coal is dried, pulverized, air-separated and circulated through a loop system of header pipes by a fan. Each furnace draws from this header what it requires, and the excess over the total requirements of the entire plant returns to the powdered coal bin for re-circulation. The mixture as circulated does not contain enough air for complete combustion, and additional air is injected into it just before it reaches the nozzles.

Mr. C. H. White, manager of the mill, stated that his company was very much pleased with the operation of the system. They were burning about 25% less fuel per ton of output, but had not yet succeeded in getting the same tonnage from the furnace as they previously did with hand firing. However, it is thought that this is largely due to the unfamiliarity of the workmen with the manipulation of pulverized fuel, and that it will be overcome in time.

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APPENDIX 17

Memorandum on Duty values for Externally Heated Retorts.

The following table has been compiled by the Board from 2 or 3 different sources, and it has not been found possible to check all the figures. The table is therefore submitted as an opinion of the Board, without guarantees and without prejudice.

Name of Plant	With agitation	Without agitation
	Capacity per sq. ft. of heating surface per 24 hours, in lbs. of coal charged into retorts.	Capacity per sq. ft. of heating surface per 24 hours in lbs. of coal charged into retort.
Coalite Plant		30
Winmill Retort	200. This figure uncertain.	
Wallace		70
Koppers By-Product Oven		43
Carbo-Coal No. 25 type of retort	390 per sq. ft. of effective surface, 230 per sq. ft. of total surface.	
Thyssen 8′ x 60′	67 per sq. ft. of total heating surface. 134 per sq. ft. of half drum.	
Lignite Board (Stansfield Retort) Bienfait Plant, at 10 ton rate	°259	
Lignite Board (Stansfield Retort) Semi-Commercial Model Ottawa, Ont.	°415	

°Agitation by action of gravity only, as lignite passes under baffles.

The above table gives the capacity of various externally heated retorts per square foot of heating surface. As will be noted there is a wide discrepancy between the capacity of the Stansfield retort semi-commercial size, as constructed at Ottawa, and the full scale example built later at the demonstration plant at Bienfait. The results obtained at Ottawa during operation of the semi-commercial model, relative to other well known retorts, appeared to be sufficiently promising to warrant the erection of the large retorts for commercial demonstration. The belief was held that the full scale unit would have a greater or at least an equal unit capacity to that of the Ottawa oven. With this belief six retorts were erected each with an estimated capacity of 16 tons of carbonized residue per 24 hours. Operations, however, revealed many disappointments in these carbonizers — the most astonishing being the actual unit capacity compared to the figured estimate based on Ottawa results. The maximum attained for any considerable period was 10 tons per 24 hours but the average was considerably below this.

A number of causes contributed to this lowered capacity, among which may be mentioned especially — (a) the difference in construction details, and (b) the difference in the screen analysis of the material retorted.

The changed constructional features brought about unexpectedly large heat losses by radiation; and as an example there may be noted the cover plates of sheet metal insulated with magnesia, where considerable heat losses occurred. Also a common combustion chamber with three large combustion flues made possible the discharge of the combustion gases at temperatures ranging from 1,000° to 1,200° F.

The alteration in the screen analysis was caused by the difference in type of crusher used, the length of dryer shell and the long storage of dried coal, all of which made an increase in the amount of dust. The presence of this dust caused a thin film of fine lignite to form on the floor of the retort, which was equivalent to the insertion of an insulating layer between the source of heat and the coal being retorted. Obviously this would effect a marked reduction in the capacity of the retort.

The above mentioned two factors played a not inconsiderable part in reducing the unit capacity of the large retorts as erected at Bienfait.

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APPENDIX No. 18

Construction and Operation of Ottawa and Bienfait Carbonizers up to December, 1921.

By EDGAR STANSFIELD.

Prior to the formation of the Lignite Utilization Board in August, 1918, the writer and other members of the chemical staff of the Fuel Testing Division of the Mines Branch, Department of Mines, Ottawa, had been engaged in researches on the carbonization of lignite. This work was commenced early in 1917. It was carried out in part at least with a view to assisting the Lignite Committee of the Honorary Advisory Council for Scientific and Industrial Research; and the experiments, therefore, were made on Souris lignite, as that was the lignite field in which this committee was most interested. The primary object of these researches was to obtain the accurate data that would be essential for the scientific design and control of a plant for the carbonization of lignite on a commercial scale, rather than to design such a plant.

This work at Ottawa did not cease with the formation of the Lignite Utilization Board, but was further carried on, though intermittently, for several years. During part of this time the Board co-operated and assisted in this work, as will be indicated later. The results of the Ottawa researches were at all times available for the use of the Board, being transmitted to them by private communication and by published reports.*

As this data on the lignite from the Souris field was the foundation of many of the decisions of the Board, it appears well to give a short summary of the available information. The original papers referred to must be consulted for fuller particulars.

Preliminary experiments to compare the results obtained by carbonization of lignite rapidly or slowly, under high, normal or low pressures, and with or without introduction of steam, indicated that little or nothing was to be gained by any deviation from the simplest procedure — that is, rapid carbonization under normal pressure without introduction of steam. This is the method followed in all the tests quoted below, except where otherwise stated. Increased pressure gave a slightly increased calorific value of residue, but the increase could not possibly justify the extra expense involved. Passing steam or carbon dioxide through the retort resulted in a slow combustion of the charge by the oxygen in these gases, with the formation of hydrogen, carbon monoxide, etc. There is thus a marked increase in the yield of gas when steam or carbon dioxide is passed through the retort; but there is a corresponding decrease both in the yield and the calorific value of the carbonized residue. This last point is of interest in connection with the many suggested processes of carbonization involving a re-circulation of the retort gases, either as the means of carrying the heat into the charge or as a means of distributing it through the charge.

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*(1) The Carbonization of Lignites, by E. Stansfield and R. E. Gilmore; Transactions of the Royal Society of Canada, Series 3 (1917), Vol. 11, page 85.

(2) The Carboaization of Lignites, Part II, by E. Stansfield and R. E. Gilmore; Transactions of the Royal Society of Canada, Series 3 (1918), Vol. 12, page 121.

(3) Lignite Carbonization, by E. Stansfield and R. E. Gilmore, assisted by J. H. H. Nicolls, T. W. Hardy and R. C Cantello; Mines Branch, Department of Mines, Ottawa, Summary Report (1918), page 87.

(4) Lignite Carbonization, by E. Stansfield, R. E. Gilmore, J. H. H. Nicolls, T. W. Hardy and others; Mines Branch, Department of Mines, Ottawa, Summary Report (1919), page 30.

These preliminary experiments also showed that the maximum calorific value of the carbonized residue was obtained with carbonization at about 1,100°F. This is clearly shown in fig. 27, based on a series of carbonization tests of lignite from the Western Dominion mine at Taylorton. In these curves the composition and analysis of the residue are plotted against the yields, and a scale indicating the temperatures involved is also given.

Table I gives typical analyses of samples from five of the principal mines in the Estevan or Souris Area. Thirty-two samples taken from twenty-six mines in the district in 1919 showed:

Moisture: Maximum, 37.7%; minimum, 28.7%; average, 35.0%.
Ash: " 16.6%; " 5.0%; " 7.7%.

TABLE I.

TYPICAL ANALYSES OF LIGNITE FROM THE ESTEVAN AREA, SASKATCHEWAN.

	W. D. Mine, Taylorton	M. & S. Mine, Bienfait	Bienfait Mine, Bienfait	Shand Mine, Shand	Estevan C. & B., Estevan
Sample Number..........	M-40	1082	1078	982	M-41
Year of Sampling.........	1908	1917	1917	1917	1908
Proximate Analysis:					
Moisture.............%	30.1	34.1	34.2	34.6	33.3
Ash.................%	5.6	7.6	6.1	8.6	11.2
Volatile Matter.......%	34.3	25.6	30.0	24.9	26.7
Fixed Carbon........%	30.0	32.7	29.7	31.9	28.8
Ultimate Analysis:					
Carbon..............%	41.8	....	....	40.8	38.5
Hydrogen............%	6.8	....	....	6.4	6.6
Ash.................%	5.6	....	....	8.6	11.2
Sulphur.............%	0.4	....	....	0.3	0.3
Nitrogen............%	0.7	....	....	0.7	0.6
Oxygen..............%	44.7	....	....	43.2	42.8
Calorific Value, B.t.u. per lb............	7,480	....	....	6,830	6,430

These analyses indicate that, with the exception of variations in ash and moisture, the coal is very much the same throughout the area.

TABLE II.

ANALYSES OF SHAND COAL — RAW, DRIED, AND CARBONIZED.

	As Mined	Dried	Carbonized at 1,075-1,110°F.	Carbonized at 1,425-1,475°F.
Proximate Analysis:				
Moisture...........%	35.0	....	....	....
Ash................%	8.1	12.5	17.5	20.3
Volatile Matter.....%	25.5	39.2	11.7	2.8
Fixed Carbon.......%	31.4	48.3	70.8	76.9
Ultimate Analysis:				
Carbon.............%	40.6	62.5	74.0	76.6
Hydrogen..........%	6.5	3.9	2.4	1.0
Ash................%	8.1	12.5	17.5	20.3
Sulphur, Nitrogen, Oxygen..........%	44.8	21.1	6.1	2.1
Calorific Value, B.t.u. per lb...........	6,660	10,240	11,920	11,800
Fuel Ratio..............	1.25	1.25	6.05	27.80
Carbon-Hydrogen Ratio..	6.2	16.1	30.8	77.4

TABLE III.

COMMERCIAL PRODUCTS, LIGNITE CARBONIZATION — MOIST COAL AS CHARGED.

Temperature of Carbonization . . °F.	660	750	885	1,030	1,120	1,275	1,380-1,475
Moisture in Coal Charged.......%	32.3	31.9	31.6	31.8	31.2	33.0	33.7
Yield, per short ton:							
Carbonized residue..........lbs.	1,185	1,075	980	910	885	825	804
Tar.......................gals.	0.1	4.1	5.4	5.3	5.6	5.0	4.0
Ammonium Sulphate........lbs.	0.5	1.4	4.4	10.2	11.8	19.2	15.0
Gas.........................c.f.	590	1,190	2,020	3,130	3,810	4,900	5,530

Gas measured moist at 60°F. and under a pressure of 30 ins. of mercury.

TABLE IV.

BALANCE SHEETS, LIGNITE CARBONIZATION.

Temperature of Carbonization . . °F.	660	750	885	1,030	1,120	1,275	1,380-1,475
Weight Balance Sheet — dry coal basis:							
Carbonized Residue..........%	87.5	79.1	71.4	66.7	64.3	61.5	60.8
Tar........................%	1.0	2.9	4.2	4.1	4.2	3.9	3.7
Gas........................%	4.1	8.1	12.3	17.0	18.0	22.1	21.7
Water of Decomposition......%	6.9	9.8	11.9	11.7	13.4	12.5	13.5
Unaccounted for.............%	0.5	0.1	0.2	0.5	0.1	0.0	0.3
Thermal Balance Sheet — Heat value of products as percentages of heat value of original charge.							
Carbonized Residue..........%	92.2	88.3	81.7	78.1	74.8	70.4	68.5
Tar........................%	1.6	4.7	6.7	6.0	6.5	5.9	4.6
Gas........................%	0.7	1.7	5.0	8.3	10.6	14.4	14.7
Loss.......................%	5.5	5.3	6.6	7.6	8.1	9.3	12.2

Note: — The lost heat in the thermal balance sheet is probably largely or entirely accounted for by the well-known exothermic reactions that take place when coal is heated. These are especially large in the case of lignites and other high-oxygen coals.

Tables II to V show some of the results obtained in the carbonization of Shand lignite, based on a series of experiments in which the products of carbonization (carbonized residue, tar, gas, ammonia, and water) were collected, measured, and analyzed. The way in which the yields and properties of these products vary with the change in the temperature of carbonization is interesting; but of greatest importance to the Board was the conclusive evidence given by these figures that both the extent and value of the by-products to be obtained from carbonizing lignite had been very commonly overestimated. This will be further considered later.

Tables VI and VII give results from a series of similar tests on coals from five of the mines in the Estevan district. Table VI shows that there were marked differences between the results obtained with the different coals. A study of Table VII, however, where the results are computed to the results that would have been given if the coal charged in each case had contained 33% of water and 7% of ash, shows that the differences noted in Table 6 are almost entirely due to the accidental variations in the ash and moisture content of the coal sample tested. Or, as stated above, with the exception of variations in ash and moisture, the coal is very much the same throughout the area.

TABLE V.

YIELDS AND ANALYSES OF PRODUCTS OF LIGNITE CARBONIZATION.

Temperature of Carbonization . . °F.	660	750	885	1,030	1,120	1,275	1,380-1,475
Water:							
Moisture in coal as charged . . . . %	32.3	31.9	31.6	31.8	31.2	33.0	33.7
Water of decomposition . . . . %	4.7	6.7	8.1	8.0	9.2	8.4	8.9
Total water . . . . %	37.0	38.6	39.7	39.8	40.4	41.4	42.6
Carbonized Residue:							
Yield, from coal as charged . . . . %	59.2	53.8	48.8	45.5	44.2	41.3	40.2
Ash content . . . . %	15.6	15.0	15.9	16.9	17.6	20.1	16.3
Calorific value . . . . . . B.t.u. per lb.	11,150	11,815	12,110	12,390	12,320	12,110	12,270
Tar:							
Density, crude tar	. . . .	0.98	0.99	1.00	1.00	1.00	1.01
Yield, dry tar per 2,000 lbs. dry coal . . . . gals.	. . . .	6.0	7.9	7.5	8.1	7.3	5.8
Calorific value, dry tar . . . . B.t.u. per lb.	. . . .	17,260	17,250	17,040	17,030	16,970	17,100
Distilled at 590°F.:							
Distillate . . . . %	. . . .	60.9	55.6	64.2*	53.7	65.2	42.6
Pitch residue . . . . %	. . . .	38.1	42.9	34.7*	43.4	32.5	57.1
Pitch, as percentage of carbonized residue . . . . %	. . . .	1.4	2.3	1.9	2.7	2.0	2.7
Gas							
Yield per 2,000 lbs.—							
of coal as charged . . . . c.f.	590	1,190	2,080	3,050	3,810	4,900	5,540
of dried coal . . . . c.f.	870	1,740	3,010	4,510	5,530	7,320	8,340
of carbonized residue . . . . c.f.	1,000	2,200	4,300	6,700	8,600	11,900	13,800
Analysis —							
Carbon dioxide . . . . %	60.3	63.0	44.9	41.5	36.1	30.3	25.0
Ethylene, etc . . . . %	1.6	2.1	3.0	1.9	2.1	1.9	1.0
Oxygen . . . . %	2.1	1.4	1.5	0.7	0.7	0.5	0.9
Carbon monoxide . . . . %	8.7	9.3	8.5	9.3	10.8	12.3	11.4
Methane . . . . %	10.9	14.1	24.9	27.1	26.6	25.8	20.0
Hydrogen . . . . %	6.4	3.2	9.7	16.4	21.0	27.2	36.1
Nitrogen . . . . %	10.0	6.9	7.5	3.1	2.7	2.0	5.6
Calorific value, gross . . B.t.u. per c.f.	180	215	355	385	405	415	370
" " net " " "	170	195	320	345	365	375	330
Density	1.22	1.24	0.96	0.94	0.86	0.79	0.69

*Cut at 620°F. instead of 590°F.

Gas yields and calorific values are in terms of cubic feet of moist gas, measured at 60°F. and under a pressure of 30-in. of mercury.

The calorific values and densities are calculated from the analysis. Densities are for dry gas compared with dry air at the same temperature and pressure.

When the Lignite Utilization Board staff commenced work in 1918, one of their first tasks was to study all the information available from the Ottawa researches, as well as that collected by the Research Council's committee. In November, 1918, the above work was sufficiently advanced to enable French and Stansfield to make an investigatory tour through the United States and Canada, with the assurance that they had the names and addresses of all the most important firms and persons who could give information, and that they themselves were sufficiently acquainted with the whole field to know what information should be sought and to profit by it when obtained. This journey took exactly two months, during which forty-one cities were visited, nine low temperature carbonization processes were investigated, and also thirteen briquetting plants and five plants burning powdered coal. In addition, a very large number of firms and persons were interviewed. The investigation was not extended to England or the continent of Europe on account of the extremely unsettled conditions there at the close of the war.

TABLE VI.

COMPARISON OF ANALYSES OF CHARGE AND RESIDUE, ESTEVAN AREA LIGNITES, CARBONIZATION TESTS AT 1,070-1,110°F.

Source of Sample	W. D. Mine, Taylorton	M. & S. Mine, Bienfait	Bienfait Mine, Bienfait	Shand Mine, Shand	Estevan C. & B., Estevan
Analysis of Charge:					
Moisture %	34.1	31.2	18.5	34.4	34.7
Ash %	6.6	8.4	7.4	11.5	9.3
Volatile Matter %	28.2	28.0	35.8	26.0	26.3
Fixed Carbon %	31.1	31.4	38.3	28.1	29.7
Calorific Value B.t.u. per lb.	7,270	7,180	8,540	6,470	6,640
Analysis of Dry Coal (calc.):					
Calorific Value B.t.u. per lb.	11,030	10,420	10,500	9,870	10,170
Yield of Carbonized Residue:					
basis of coal charged %	42.8	45.0	52.2	45.3	43.6
basis of dry coal %	65.0	65.4	64.1	69.1	66.8
Analysis of Residue:					
Ash %	14.3	16.7	12.3	24.3	20.2
Volatile Matter %	9.1	9.9	9.7	8.7	9.3
Fixed Carbon %	76.6	73.4	78.0	67.0	70.5
Calorific Value B.t.u. per lb.	12,820	12,190	13,050	11,360	11,990
Gain in Calorific Value on carbonization:					
from coal as charged %	76.2	69.6	52.6	75.2	80.4
from dry coal %	16.2	16.9	24.3	15.1	17.9

It had been thought that as a result of this investigation it would be possible to recommend specific processes and equipment to the Board for adoption in the commercial plant they proposed to erect in southern Saskatchewan. The above engineers reported, however, that in their opinion no suitable carbonizer was available, and that, although many suitable makes and types of driers and briquetting equipment were available, little was yet known from practical experience in North America of either the drying of raw lignite or the briquetting of carbonized lignite. The engineers therefore recommended to the Board the prosecution of further experimental research with the special view to the development of a suitable type of carbonizer, this to be followed by research on the briquetting of lignite in a commercial type of press. This recommendation with regard to the carbonizer largely depended on a matter of policy with regard to by-products. Most of the writers on the subject of lignite carbonization had claimed the production of large yields of such by products as gas, tar and ammonia, and had stated that in commercial operation the sale of these by-products would pay, or largely pay, for the operation of the plant. The Ottawa researches, on the contrary, had clearly proved that the production of gas, tar, and ammonia, had been greatly overestimated. In this connection it should be explained that the gas yield can be made considerable, but only at the expense of carbonized lignite, which, for the Lignite Utilization Board, was the main objective. A very careful study of the whole situation convinced the Board that the gas normally produced (that is, the gas produced otherwise than by burning up the carbonized lignite) would scarcely be sufficient in amount to supply the heat required to dry and carbonize the lignite treated; and that, in the immediate future, the ammonia would not, and the tar probably would not, pay interest on the large capital and working charges involved in their recovery and conversion into marketable by-products. This decision with respect to by-products has been challenged from time to time, but further developments have all gone to show that a contrary decision would have been almost certainly fatal to any hope of success. It

TABLE VII.

COMPARISON OF YIELDS AND ANALYSES OF PRODUCTS, ESTEVAN AREA LIGNITES, CARBONIZATION TESTS AT 1,070-1,110°F.

Results computed to the common basis, as from coals containing 33% moisture and 7% ash.

Source of Sample	W. D. Mine, Taylorton	M. & S. Mine, Bienfait	Bienfait Mine, Bienfait	Shand Mine, Shand	Estevan C. & B., Estevan
Water:					
Moisture in coal charged . . . %	33.0	33.0	33.0	33.0	33.0
Water of decomposition . . . %	8.4	8.9	8.7	8.5	8.6
Total water . . . %	41.4	41.9	41.7	41.5	41.6
Carbonized Residue:					
Yield, from coal as charged . . . %	43.5	43.3	43.7	43.9	44.0
Ash content . . . %	14.9	14.6	14.5	14.8	14.7
Calorific value . . . B.t.u. per lb.	12,800	12,700	12,700	12,750	12,600
Tar:					
Yield, dry tar per 2,000 lbs. coal . . . gals.	6.9	6.4	4.2	4.9	5.0
Pitch, as percentage of carbonized residue . . %	3.6	2.9	2.2	2.1	2.3
Gas:					
Yield per 2,000 lbs.—					
of coal as charged . . c.f.	3,260	3,340	3,320	3,310	3,210
of dried coal . . . c.f.	4,870	4,990	4,960	4,940	4,790
of carbonized residue . . . c.f.	7,500	7,720	7,610	7,540	7,310
Analysis—					
Carbon dioxide . . . %	40.2	40.0	44.4	39.9	42.7
Ethylene, etc. . . . %	2.6	2.5	1.9	2.3	2.3
Oxygen . . . %	0.4	0.3	0.3	0.3	0.3
Carbon monoxide . . . %	9.4	9.4	10.7	9.2	9.9
Methane . . . %	28.9	28.0	27.1	28.9	26.8
Hydrogen . . . %	16.3	18.3	14.0	17.3	15.9
Nitrogen . . . %	2.2	1.5	1.6	2.1	2.1
Calorific value, gross . . . B.t.u. per c.f.	415	410	380	410	390
Calorific value, net . . . B.t.u. per c.f.	375	370	345	370	350
Density . . .	0.93	0.91	0.98	0.92	0.95
Ammonium Sulphate:					
Yield, per 2,000 lbs. coal . . . lbs.	11.1	11.8	11.1	12.0	11.6

should, however, be pointed out that the development of a by-product industry is an aim which must not be forgotten, and that in the years to come, when a carbonization industry is firmly established, the commercial possibilities of the by-products may become considerable. At the time, however, it would have been very poor policy to invest capital in a by-product industry in southern Saskatchewan. This point has been treated at some length, as it is of vital importance, and one on which widely divergent views have been held.

Almost all the carbonization schemes submitted to the Board claimed as their chief advantage the large yields of by-products which they gave. Many of them, moreover, were designed primarily to handle coking coals, although they could also treat the non-coking lignites. The complications involved by the desire to increase the yields of by-products and by the necessity to handle material which becomes sticky when heated made them appear in every case to be unduly costly. The Board felt that, to handle with commercial success a low-grade fuel where there would be no profits accruing from by-products, required a carbonizer of high capacity, low capital cost, and low operating cost. They decided that none of those considered met these requirements, and that, until they could either design one themselves or find one more suitable, it would be a mistake to proceed with commercial work. Further experimental work with the above idea in view was therefore to be proceeded with, also further work on drying and briquetting.

The Board therefore arranged for the continuation of its research programme. The possibility was considered of carrying this on near the offices of the Board, at McGill University or elsewhere in Montreal; but it was decided that the only practical scheme was to continue it in connection with the Fuel Testing Laboratories of the Mines Branch in Ottawa. A co-operative agreement was therefore entered into by the Board and the Department of Mines to permit the research work to be continued in Ottawa. Under this agreement, which was approved on January 20th, 1919, an intensive and thorough investigation was carried on until the summer of 1921. It is worth noting at this point that on account of the thoroughness of the earlier investigations further progress followed rapidly. In January, 1919, therefore, the writer devoted himself to the question of the best type of carbonizer for lignite to meet the Board's requirements.

One of the first requisites for any carbonizer design is to get an approximate figure for the heat necessary to carbonize the lignite. Hollings and Cobb discuss the thermal phenomenon during carbonization in a paper published in the Transactions of the Chemical Society, 1915, *107*, 1106. They give and discuss some quantitative results of earlier workers, and also give some painstaking qualitative results of their own.

They quote Mahler as finding that the aggregate heat value of the products of distillation of Commentry coal were 3.5% less than the heat value of the original coal. They state that this is usually assumed to be the quantity of heat evolved as a net result of the chemical actions taking place during distillation, and is therefore not available as potential energy in the products. They point out, however, that this assumption is only correct if the thermal capacity of the coal between ordinary temperatures (at which the calorific value is determined) and the mean temperature of decomposition is the same as the thermal capacity of the products between the same temperatures. Unfortunately no reliable figures are available for the mean specific heats of coal and some of its products, and they estimate that the difference between the thermal capacities may be large compared with the above figure of 3.5%.

They quote other authors to show that in twenty-eight European coals the loss in aggregate calorific value on carbonization varied from 2.1% to 7.2% of the net calorific value of the coal. The loss tends to increase with the oxygen content of the coal. These figures are in good accord with those shown in Table IV, where the loss with lignite, which is a particularly high-oxygen content coal, amounted to 8.1% of the gross calorific value when carbonized at 1,120°F.

Assuming for the time that this loss does represent the heat evolved during distillation, the following calculations give an approximate idea of the heat evolved during carbonization. A number of assumptions will have to be made. Thus: that the temperature of carbonization is 1,120°F., or 1,060°F. above room temperature; that the mean temperature of the gaseous products leaving the retort is 700°F., or 640°F. above room temperature; that the mean specific heat of the carbonized residue up to 1,120°F. is 0.4, and the mean specific heats of the tar and gas up to 700°F. are 0.6 and 0.3, respectively; also that the heat required to convert water at 60°F. to steam at 700°F. is 1,350 B.t.u. per pound.

The gross calorific value of the lignite employed in the tests represented in Table IV was about 10,500 B.t.u. per pound of the dry coal: that is, the heat evolved in carbonization at 1,120°F. amounts to 8.1% of 10,500, or 850 B.t.u. per pound of dry coal. The heat required per pound of dry coal to heat the solid and gaseous products up to 1,120°F. and 700°F., respectively, are as follows, for the weights taken from Table IV:—

Coke:	0.643 ×	1,060 ×	0.4	=	273
Tar:	0.042 ×	640 ×	0.6	=	16
Gas:	0.18 ×	640 ×	0.3	=	35
Water of decomposition:	0.134 ×	1,350		=	181
Total..................					505

Therefore, from these calculations the heat evolved during the carbonization by the decompositions effected is 850 B.t.u., and the sensible heat of the products is 510 B.t.u., leaving a net balance of 340 B.t.u. evolved per pound of dry coal carbonized.

Tests were made to determine this value experimentally. A charge of dry coal was carbonized in an electrically heated retort. The coal was charged into a cold retort, and the retort and charge gradually raised to 1,075°F., and held there until the evolution of gas had practically ceased. Careful record was kept of the temperature of the retort at regular time intervals throughout the experiment, and also of the quantity of electricity required. An empty retort was then similarly heated with the current so regulated that the retort was heated at the same rate as before, and the heat maintained at 1,075°F. for the same time. The current consumption was measured as before. The current consumption in the second experiment gives a measure of the heat required to raise the temperature of the retort and furnace to the requisite temperature, and to make up for radiation and other losses. The difference between the current consumption of the first and second experiments gives a measure of the heat required to carbonize the charge. The experiment is unsatisfactory, as the quantity required is measured as the difference between two large amounts. A small percentage error in either of the tests, therefore, causes a large percentage error in the value required. The mean of two reasonably concordant results showed that 380 B.t.u. are required per pound of dry lignite charged. In other words, calculations based on the heat value of the charge and its products show an evolution of 340 B.t.u., whilst the experiments show an absorption of 380 B.t.u. per pound of dry lignite. This discrepancy may be due to errors in the experimental determination, or may be due, as suggested by Hollings and Cobb, to faulty assumptions on which the calculations are based.

The effect of moisture in the coal is important. If the moisture is driven off in the retort, escaping with the other gases at 700°F., each pound of water will require approximately 1,350 B.t.u. If, on the other hand, it is driven off in a drier, escaping at, for example, 212°F., it will only require 1,120 B.t.u. Assuming, then, that carbonization requires 380 B.t.u. per pound of dry coal, and drying in the retort requires 1,350 B.t.u. per pound of water, the total heat required per pound of coal charged will decrease 1% of 380 B.t.u. and increase 1% of 1,350 B.t.u. for each 1% of moisture present: that is, a net increase of 9.7 B.t.u. If the value of —340 were taken instead of +380, the net increase for each per cent of moisture would be 16.9 B.t.u.

Experimental proof of the conclusion that the doubtful value of the heat for carbonization is small compared with the fairly definite value of 1,350 B.t.u. was given by the repeated observation later in large scale carbonization runs, that a small increase in the moisture content caused a very marked decrease in the capacity of the retort.

If the drying is carried out partly in a drier and partly in the retort, it may be assumed that 1,200 B.t.u. are required for each pound of water. If the higher of the two values arrived at above is assumed for the heat of carbonization, then to dry and carbonize one pound of coal with 33% of water would require (0.33 × 1,200) + (0.67 × 380) = 396 + 255 = 650 B.t.u., of which 60% will be required for drying and 40% for carbonizing.

One pound of this coal with 33% of water might be expected to give off, on carbonization at 1,120°F., 1.85 cu. ft. of gas with a gross calorific value of 405 B.t.u., or a total available heat of 750 B.t.u. An over-all efficiency of 87% in carbonizer and drier would therefore be essential if they are to be heated entirely by the burning of the gas produced. If the tar were also to be burned, some further 450 B.t.u. would be available, or a total of 1,200. This would only require an over-all efficiency of 54%.

In the preceding calculations the high value of +380 B.t.u. required for carbonization was taken. The low value of —340 B.t.u. deduced from determinations of calorific values was entirely ignored. Although this latter value, like the former, is liable to considerable error, it hardly seems possible that it is 720 B.t.u. too low. If the mean value is accepted, then the total heat required as above becomes 410 B.t.u. instead of 650 B.t.u., and the required efficiencies are: 55% for gas alone, and 35% for gas and tar.

Some values of the heat required for the carbonization of coal and peat are given below; but several of these, it should be pointed out, are for high temperature carbonization of coking coals. The lower temperatures required for lignite carbonization should permit of marked reduction of the heat required; also the lignite gives out more heat in its decomposition. On the contrary, the coal charged would be comparatively dry, which would require, other things being equal, less heat than would be required for the lignite. Furthermore, the fact that in the examples cited the hot flue gases from the retort escape up the chimney, whilst in treating lignite they might be used in direct contact with the coal for driving off the more than 30% of moisture it contains, should permit of a very large increase of over-all efficiency of operation. On the whole, it seems reasonable to expect that lignite would require very distinctly less heat per pound for its treatment than the figures cited below for coal.

(1) A seven-day trial in 1910 with a modern horizontal retort setting (Transactions of the Institute of Gas Engineers, 1910, page 259) showed for 12-hour charges 1.60, and for 8-hour charges 1.65 cwts. of coke per ton of coal charged. The average retort temperatures were 1,820°F. and 1,810°F., respectively. If the coke is assumed to have a calorific value of 14,000 B.t.u. per pound, the above figures average 1,140 B.t.u. required per pound of coal treated.

(2) A test on 140 tons of coal in a Glover-West installation at Manchester (Transactions of the Institute of Gas Engineers, 1911, page 129) showed a consumption of 9.37 pounds of coke (13,750 B.t.u. per pound) per 100 pounds of coal: that is, 1,290 B.t.u. per pound of coal treated. In this test the aggregate heat value of the products was 2.65% less than the heat value of the coal charged.

(3) In tests made by the British Fuel Research Board (Report for the years 1920-21, Table 9) in a Glover-West installation, the smallest consumption of heat (Test B) was 1,510 B.t.u. per pound of coal treated.

(4) In another test made by the same Research Board (Technical Paper 4) in the same Glover-West installation, 11.01 tons of 20% moisture peat were carbonized in 18 hours at a temperature of 1,832°F. with a consumption of 3,480 cu. ft. of gas per hour. The gas had a calorific value of 325 B.t.u. per cubic foot. The consumption of heat was therefore 830 B.t.u. per pound of peat treated. It is suggested in the report that the heat consumption is possibly low, but that the error is unlikely to exceed 5%. This case more closely resembles the carbonization of lignite than does the previous ones, but it should be noted that the temperature of carbonization in this test is about 700° higher than that desired for the lignite.

(5) In yet another test made by the above Research Board (Technical Paper 7) in their Glover-West installation, a coking coal was carbonized at about 1,430°F. a low temperature for the installation, and yet higher than that required for lignite. The coal charged contained 6.5% moisture. The aggregate loss of calorific value on carbonization amounted to 3.7%, or 462 B.t.u. per pound of coal charged (corresponding to 850 B.t.u. per pound of dry lignite at 1,120°F.). The following table shows the heat consumption per pound of coal fired.

Heat dissipated from setting	693 B.t.u.
Heat dissipated from pre-heater	54 "
Heat lost in flue gases	415 "
Heat given to coal	282 "
Total	1,444 B.t.u.

The high value of the total heat is quite natural in view of the fact that low temperature carbonization was carried out in a retort designed for high temperatures. Comparison with lignite values is of interest.

	Coking Coal at 1,430°F., B.t.u. per lb.	Lignite at 1,120°F., B.t.u. per lb.
(*a*) Heat required to decompose coal? (from aggregate loss of calorific value on carbonization)................	—462 (determined)	—850 (determined)
(*b*) Heat required to raise temperature of products of combustion..........	+744 (by difference)	+510 (by calculation)
(*c*) Net heat required for carbonization.	+282 (determined)	—340 (by difference)

This difference between the nature of the coals fully accounts for the difference in values in line (a). The lower temperature of carbonization of the lignite would explain the lower value in line (b), so that the value of —340 B.t.u. in line (c) would appear to be reasonable. The error could hardly be greater than that allowed for in taking the mean between —340 and +380.

(6) In an unpublished test made in June, 1922, with an electrically heated lignite carbonizer of a type to be described later it was found that when the lignite charged contained 13.8% of moisture and the carbonization was carried to a degree giving a discharge with 13.8% of volatile matter, the electrical energy supplied amounted to approximately 1,000 B.t.u. per pound of charge. This was in a very small retort with a capacity of approximately 12 pounds per hour, so that the radiation losses might be expected to be very high as compared with large scale operation.

A number of the cases cited are of later date than the period at which the Lignite Board was making a decision with regard to a design for a carbonizer. They are, however, quoted here as giving more reliable information than those studied at the time; yet they but serve to confirm the opinion then formed.

In conclusion, therefore, there appeared to be justification for assuming that the gas evolved during lignite carbonization should be ample to provide all the heat required for carbonization if a reasonably efficient retort were designed. It also appeared to be just possible that this heat would also dry the lignite, but this point was so doubtful that it was evidently advisable to be prepared to supply supplementary heat for this operation.

A study of Figure 28, based on the Ottawa tests on the carbonization of Shand lignite, gives an idea of one of the requirements to be considered in the design of a carbonizer in order to obtain the best possible results. The curves show that the maximum calorific value of the residue is obtained by carbonization at about 1,050°F. It also shows that at this temperature we might expect a yield of carbonized material of 66% of the weight of dry coal taken. This material would have an analysis of:—

Fixed carbon.....................	77 %
Volatile matter..................	11½%
Ash............................	11½%
Calorific value..................	13,560 B.t.u. per lb.

If, however, instead of being carbonized in a small retort with an exact temperature control, the coal were carbonized in a commercial-sized retort, it is clear that, whilst it might be subjected to a temperature which averaged 1,050°F., yet the coal nearest the walls might be heated to 1,300°F., and the coal in the centre of the retort only heated to 800°F. The curves show, further, that the yield from the coldest pieces, under these conditions, would be 77%, and from the hottest, 61%; but the average yield, as before, would be close to 66%. The fixed carbon would vary from 65% to 82½%, the volatile matter from 25% to 5%, and the ash from 10½% to 12½%; but the average would in each case be reasonably close to the analysis at 1,050°F. The calorific value, on the other hand, would be about 13,000 B.t.u. for the coldest pieces, rising to 13,560 B.t.u. for those carbonized at 1,050°F., then falling again to about 13,300 for the hottest pieces The average in this case could not be 13,560 B.t.u., but would fall some 200 B.t.u. lower It follows, clearly, that the further apart are the maximum and minimum temperatures of carbonization, the lower will be the average B.t.u. of the product; or, the more nearly each particle is carbonized at the optimum temperature, the higher will be the average B.t.u. of the product.

This requirement could be met in an ordinary shaft retort by maintaining the heating flue at the desired temperature and passing the charge so slowly through the retort that every particle of coal attained to this temperature; or by making the thickness of the charge so small that all parts were at approximately the same temperature. It could also be met by keeping the charge thoroughly mixed, as in a rotary retort, whereby the same result would be attained. Construction difficulties caused a decision against the third method. The first two were ruled out on account of the consequent small output per retort.

Another method for achieving the desired ends was then considered: that of subjecting the coal in a thin layer to a very high temperature, but for such a short time that the coal could only attain to the desired temperature. In other words, obtain the uniformity of temperature by the thinness of the charge, and the high output by the use of high temperature and consequent rapid carbonization. Control of degree of carbonization in such a process would be by regulation of the time of carbonization rather than by regulation of the temperature in the heating flues.

The possibility of this method was tested by the experiment of heating for varying short times a thin layer of coal in a muffle heated to nearly 400°F. higher than the desired temperature of carbonization. (See Mines Branch Summary Report for 1919, page 36.) Tests were made with a half-inch layer and with a one-inch layer of lignite, and the results are shown graphically in Figure 29. As would be expected from the above discussion, the residue from the half-inch layer had a higher calorific value than had that from the one-inch layer. The former value, it might be noted, was only slightly more than 100 B.t.u. lower than that obtained by complete carbonization in a retort with careful temperature control. Table VIII gives the results obtained by complete carbonization of the same lignite at 1,095°F. and at 1,110°F. with the optimum results for half-inch and one-inch layers carbonized in a muffle at 1,475°F., as taken from the rounded curves of Figure 29.

TABLE VIII.

COMPARISON OF COMPLETE AND RAPID CARBONIZATION.

Method of Carbonization	In Lead Bath		In Muffle	
Temperature °F.	1,095	1,110	1,475	1,475
Thickness of Layer ins.	....	....	½	1
Time of carbonization minutes	Until completed	Until completed	5	9
Yield %	67.5	67.1	69.2	67.0
Ash %	18.9	18.9	18.7	19.4
Volatile Matter %	8.7	8.4	9.0	7.9
Fixed Carbon %	72.4	72.7	72.3	72.7
Calorific Value B.t.u. per lb.	12,170	12,150	12,040	11,860

No great accuracy is claimed for these muffle tests, but they proved the point in question, and it was not thought worth while to make more careful tests at that time.

In the modern high temperature coke oven, the coking period in recent years has been reduced to 12 hours, in retorts where the thickness of charge is only 12 inches. In the tests described above, lignite was carbonized in five minutes by reducing the thickness of the charge to one-half inch. A design was now required for a furnace in which this process could be carried out. The first suggestion of importance was the shaft carbonizer indicated in Figure 30. The main idea of this was, briefly, that of a series of muffle chambers one above the other. The baffle plates shown were inclined at an angle (45°) slightly greater than the angle of repose of carbonized lignite, which was found to be about 37°. In this way the coal would slide down through the retcrt from baffle plate to baffle plate. The thickness of coal on any plate would increase downwards as shown, being controlled by the distance between the two baffle plates at the top and by the difference between the angle of repose of the coal and the angle of the baffle plate, in this case 8°. The rate at which the coal flowed through the retort could be controlled by the rate of rotation of the discharge wheel at the bottom. In each pocket or muffle chamber the coal would be subjected to heat radiated from the wall separating the chamber from the heating flue. The gas evolved would pass into the central offtake flue. In the diagram a pair of such retorts

are shown. The coal thickness, as shown, would average four to five inches, but in view of the mixing which would occur at each passage from one chamber to the next it was thought that uniform carbonization would be effected in spite of the thickness.

In the retort sketched, each baffle plate is approximately three feet by four feet. If there were fifteen baffles in each retort, the total charge in the double retort would be about three tons. If a thirty-minute treatment were required, then the capacity would approximate 100 tons of discharge per day.

This design was tentatively submitted to the Board by the writer, but was abandoned by him almost immediately. Experiment confirmed the fear that the gases evolved would become cracked in contact with the hot walls of the retort. The carbon that would thus be deposited on the walls would impede the heat transfer, and would steadily reduce the retort capacity until it became necessary to stop operation to burn off the carbon. Furthermore, some rough calculations indicated that it would be impossible to pass the heat through the walls at the required rate, even though the heating flues were maintained at a temperature far above economical suitability, and the walls were made of only single thickness firebrick construction.

A second design was submitted by the writer a few days later, and on February 10th 1919, it was accepted by the Board as sufficiently hopeful to warrant testing. In this design, which is shown in Figure 31, the retort was inclined instead of vertical, and the coal was heated from below instead of by radiation from the walls. The chamber feature was maintained, and also the feature of a gradually increasing thickness of charge as the coal passes down through each chamber, this change in thickness, as before, depending upon the difference between the inclination of the plates over which the coal flows and the angle of repose of the coal. As before, also, the passage from one chamber to the next would cause a mixing of the charge. In this design, however, the coal rests directly upon the heated plate, so that as the plate is cooled by the coal on its upper surface the temperature gradient through the plate could be far greater than if it was only cooled by radiation as in the earlier design. Moreover, the plates over which the coal travels could be made of thinner material than would be possible for the wall of the shaft type. The gases rising from the heated coal in the inclined design pass off through the offtakes provided in the chamber covers without coming in contact with any strongly heated surface. Cracking of the gases is thus reduced to the minimum. The construction suggested is shown in the drawing. It was proposed to divide the retort into two or more parallel channels for the sake of structural strength and simplicity. The coal would be fed in through a hopper at the top, and pass down through the retort, over the heated floor plates, and under the baffles. It would leave the retort through the discharge wheel, and flow into a cooling chamber. The gas evolved from the coal would pass off through the different offtake pipes into a common pipe, then through the purifying system and back to the gas burner. The air for combustion of the gas would enter through an intake and pass down a pre-heating flue to the burner. It would become heated whilst passing down the flue, carrying back to the combustion or heating flue the heat which had escaped through the floor of that flue.

Calculations in this case indicated that the design was a possible one, but they made it clear that it would be advisable that the floor plates should be as thin as possible, and made of the best conductor of heat that would stand the conditions involved.

Practical tests of this design followed two lines. One was that of small scale models erected in the laboratory and heated by electricity instead of by gas. The coal channel in these models was usually only two inches wide, but varied in length from about three to six feet. It is not proposed to include a description of these retorts in this report, but the experience gained with them was extremely valuable, and a number of points brought out will be discussed later. The other method of test consisted in the erection and operation of a semi-commercial sized retort out of doors on the grounds of the Fuel Testing Station at Ottawa.

The advantage of small scale electric models was the ease and rapidity with which they could be constructed, tested, modified, and retested. The first one was not begun until the plans for the large-scale model were under way, yet the first test was made with it on April 24th. This model, even after several changes had been tried, was an unmitigated failure so far as operation was concerned; but the information gained from it was very useful later. The second electric model was not begun until July 13th. Experiments with this model were carried on simultaneously with the large scale tests. The results with it were on the whole so satisfactory as to give reasonable certainty that the large scale model could be successfully operated, even when, in the earlier days, the results with that model were discouraging.

The working drawings of the carbonizer to be erected in Ottawa were prepared in Montreal by R. deL. French, assisted by H. R. Evans. They were practically completed by March 21st. Tenders were then called for, and orders placed. Construction was commenced about the middle of April.

Figure 32 gives a longitudinal section of the carbonizer proper, and Figure 33 is a side elevation showing the general arrangement. The sectional drawings in Figure 32 show that in essential features the design closely followed the original suggestion. There was a heated flue situated under an inclined, stepped, carbonizing floor, down which the coal flowed by gravity from a feed hopper at the top. The thickness of the coal on the carbonizing floor was controlled by a series of baffle plates under which the coal had to flow. The rate of flow of the coal was controlled by a hand-operated discharge wheel. The treated coal, after passing the discharge wheel, fell into a cooling hopper from which it was withdrawn from time to time through a spout containing a number of cooling coils. The baffle plates, with the concrete covers over them, formed a series of gas chambers through which the gases from the coal passed on their way to the offtakes shown in the side of the chamber. Observation holes were provided in the cover. Pyrometer holes were provided close to the bottom of each baffle, also in the heating flue and in the air preheating flue, as shown. The gas burner for heating the carbonizer was placed at the bottom of the heating flue as shown. The products of combustion were caused to follow a staggered path along the heating flue by means of the baffles shown in the general section and in the section G-H. At the top they passed out through a short, horizontal pipe to the stack. The air for combustion of the gas was supplied by a small blower connected to the air intake, and then passed down the air preheating flue on its way to the burner. It might be noted that there was only one channel in this carbonizer instead of the two or more parallel channels proposed in the original design. This channel was about eleven inches wide, as shown in the section E-F.

The general arrangement is shown in Figure 33. It will be seen that the carbonizer proper was carried on a steel girder frame. This was pivoted at the bottom, and was supported at the top by a pulley block and wire rope from a tall wooden gallows. The furnace was expected to be operated with an inclination of 45° on the floor plates, but it was designed as above in order that other inclinations might be tested. Figure 33 also shows a small coal-fired furnace which was used for the preliminary heating of the carbonizer. This furnace was connected to the bottom of the heating flue by means of a jacketted flue pipe. It was proposed to use the lignite gas for heating after the retort was in full operation, but city gas was also provided for use as required. The gas outlets are shown in this drawing connected to an inclined downtake pipe. It was proposed to connect this foul gas main to a cooling and purifying system; but as a matter of fact this was never done, and city gas was used for heating in all the tests. The stack is shown on its concrete foundation, with the flue pipe from the carbonizer to the stack.

In the first design for the Ottawa carbonizer it was proposed to use firebrick slabs 12″ x 12″ x 12″ for the carbonizer floor, as shown at the left of Figure 32 in a double-scale inset. Later it was decided to use carborundum slabs of only one inch thickness in order to increase the capacity. This necessitated the use of a small filler in order to avoid further changes in construction. This arrangement is shown in a second inset under the above in the same diagram. There was a delay in the delivery of the carborundum slabs, so that it became necessary to use some substitute. The retort was therefore built with cast iron floor plates. These were made with small side plates to support the baffle plate in the desired position. The floor plates are shown to double scale with side plates complete on the right hand side of the drawing, but in the general section and in the following Figures 34 and 35, etc., the side plates are only shown on the lowest floor plate to avoid confusing the drawing. The original floor and baffle plates were designed to be placed in suitable grooves in the side walls, as shown in section E-F. When it became necessary to temporarily substitute the cast iron plates, it was arranged that the upper part of the retort should be the full width of the plates to permit their ready withdrawal and replacement. It was this change that necessitated a new form of support for the baffles.

It may be noted that an expansion joint was provided in the floor and walls between the common brick and the fire brick. In the floor and on one side this joint was filled with sand, and on the other side it was filled with slag wool.

From time to time the construction of the carbonizer was changed. These changes are shown in Figures 34 to 40, entitled "Modified Construction". The first of these shows, on the same scale as the others for purposes of comparison, the retort

as constructed and as operated in the first real run on July 18th, 1919. Subsequent changes and the reasons for them will be described later

The carbonizer was first heated on July 11th, and first run on July 18th. It was subsequently run from time to time, with intervals for modification, until November 21st, when winter conditions compelled a shut-down. At that time most of the desired information had been obtained, and it did not appear advisable to build the necessary covering building to permit of winter operation. The carbonizer, during the above period, was operated on forty-eight different days. Details of some of these runs follow.

It should be noted at this stage that the carbonizer was designed to operate on dry lignite, not on lignite as mined. It was also designed to operate on crushed coal. The equipment available for crushing the coal was a set of rolls belonging to the Mines Branch, for which the Board provided special fluted rolls. The only equipment available for drying the coals was a gas-fired, rotary retort belonging to the Mines Branch, and originally designed by the writer for carbonizing tests. This retort, after modification of the feeding device, proved quite satisfactory as a dryer, but its capacity was far below that of the carbonizer, as it only gave an output of about sixty pounds of dried lignite per hour; so that it was essential to operate the crusher and dryer for long periods in order to store up raw material for comparatively short runs of the carbonizer. This necessity materially curtailed the running of the carbonizer.

The usual procedure in a run was somewhat as follows. The carbonizer was gradually heated by means of the coal-fired furnace, first using natural draft, then, later, forced draft. The gas burner was then lit, and the carbonizer further heated. Carbonized or partially carbonized lignite was then charged in to fill the carbonizer and hopper, and the discharge wheel then started. At first the rate of discharge was kept very low, but this was increased from time to time as the temperature increased. When the carbonizer appeared to be suitably heated, and everything working smoothly, dried lignite was fed into the hopper as required for the remainder of the test instead of carbonized lignite.

The rate of operation of the carbonizer was controlled by the discharge wheel shown in the drawings. This was hand-operated by a wheel outside the hopper. The wheel was marked to show the correct amount to turn from each bucket to the next. When the furnace was in operation the wheel was given a one-sixth turn, that is, one bucket was discharged, at regular time intervals. This time interval commonly varied from one to three minutes, as arranged. The capacity of each bucket was three and one half pounds, so that to discharge every three minutes corresponded to a discharge of seventy pounds per hour, every two minutes to one hundred and five pounds, and so on.

Temperatures were recorded by means of indicating pyrometers. These were commonly located in the following places: in the charge; in the first, fourth, and eighth compartments, numbered from the bottom; in the top opening into the heating flue; and in the bottom, or bottom but one, opening into the air preheating flue.

In full runs, samples of the charge and of the discharge were taken from time to time and analyzed, the coal charge was weighed, regular records of the temperatures were kept, also gas meter records, discharge rate records, and, frequently, flue gas analyses and screen analyses of the charge and discharge. Also any special features were recorded.

In the following diary of the operation of the Ottawa carbonizer the periods are numbered, corresponding to those in Figures 34 to 40, inclusive.

Period 1. — *Run 1, on July 18th.* — The carbonizer was brought up to heat, and lignite then fed in. Difficulty was at once encountered, as it was found that coal would not feed down steadily under the baffles without constant poking. The brickwork of the carbonizer, also, leaked badly. The sides opened up with the heat, creating large openings between the sides and the cover plates.

MODIFICATIONS. — The original drawings called for ¼-inch clearance past the baffles, but this had been increased to ⅜-inch during construction. Tests showed that ½-inch clearance was required around the baffle with the dried coal on hand for the tests. This coal was slightly coarser than that used in the earlier tests with the laboratory model, and on which the design of ¼-inch had been based. The carbonizer was therefore modified to give a clearance of 1-inch around the baffles. New covers were also constructed, 18 inches long, to rest on the side walls, instead of being only 12 inches long, inserted between them. This change, therefore, allowed movement of the side walls without the creation of serious leaks. It also had the effect of raising the covers of the carbonizers about two inches, making a larger gas space above the

coal. The covers, therefore, no longer rested on the baffles as before. Fillers, however, were put on two of the baffles to close the space between them and the covers. This resulted in there being three distinct gas chambers instead of eleven as before.

It might be noted at this point that it was never found possible to keep the brickwork gas-tight. It was therefore decided not to attempt to collect, measure, and burn the lignite gas, but to let this escape to the air and to use city gas entirely for the heating. Trouble, moreover, was experienced in most of the runs with blocks in the gas offtake pipes. These blocks were due to the dust rising with the gas and depositing with the tar in the offtakes. This mixture of tar and dust frequently baked to an extremely hard material that was very difficult to remove. The reduction from eleven gas chambers to three was an advantage, as it gave alternative outlets for the gas from every chamber if one or two of the pipes became blocked. Also these offtakes could be cleaned without interfering with the operation of the retort.

These modifications are indicated in Figure 35. The width of the carbonizer chamber was eleven inches. Other details not shown were as before.

Period 2. — *Run 2, July 29.* — This run was stopped very shortly, as a large leak was found from the heating flue into the carbonizing chamber under the bottom floor plate. This leak was afterwards stopped.

Run 3, July 30. — Ran about 1,500 pounds of coal through the carbonizer, but had trouble with the discharge, as coal flowed past this when wheel was at rest.

Run 4, August 1. — Discharge now in order. Had trouble with blocking in one of the lower compartments. A workman, trying to remedy this by poking, knocked down a baffle plate and displaced a floor plate, necessitating a shut down of the run.

MODIFICATIONS. — Examination of the cast iron floor plates showed that the lower ones had suffered from the heat and were seriously burned and buckled. A small consignment of four carborundum slabs had arrived by this time, so these were put in to replace the lower four cast iron plates. Incidentally, it became necessary to find a new method for supporting the baffle plates. Also, in replacing the cover plates, the two fillers previously referred to were omitted so that the whole gas space constituted a single chamber. It will be noted in Figure 36, that these carborundum slabs were laid flat, not stepped, so that the inclination of the floor on these plates was 56° instead of 45° as on the cast iron floor plates, and as designed.

As rebuilt, the lower three and a half plates were carborundum, the others cast iron. The width for the upper seven chambers was eleven inches, as before, and in the lower four chambers, twelve inches. The capacity of the retort between the entrance to the discharge spout and the rod across the feed hopper, under running conditions, was 104 pounds after this reconstruction.

Period 3. — *Run 5, August 6.* — A difficulty was experienced in this run before the furnace had really come up to full heat on account of interruptions and low voltages in the electric current supply. This interfered with the motor-driven air blower, and the run was therefore abandoned five hours after the discharge was first started.

Run 6, August 8. — Before commencing this run, cleaned up the gas offtakes which were choked, also cleaned several baffle openings which had become choked with bits of rubbish, presumably fed in with the carbonized coal when starting the trials. After this test a six-inch mesh screen was kept over the feed hopper to eliminate this difficulty with choking. The test was continued all day without any notable difficulty. During the afternoon the rate of discharge was 70 pounds per hour. The temperature of the retort was rising steadily all day. At the end of the run analysis of the carbonized material showed 8% of volatile matter. The coal charged contained 7.5% moisture.

Experience gained in the attempted operation of the first electric model had indicated that it would be necessary to keep a graded heat along the floor of the carbonizer chamber: very hot towards the bottom end, but cool towards the top end. The reason for this is as follows. If a layer of cold material entering from the hopper at the top is fed on to a very hot plate, the tarry gases liberated from the coal touching the plate are condensed as they pass through the cold upper layers of the coal. This then becomes sticky, does not flow under the baffle, and prevents steady operation. If such a block is formed, operation of the discharge removes the coal below it, and the exposed plates become very hot. After a while the tarry coal causing the block becomes heated, the tar distills off, the material begins to flow again, and there is a rush of coal from the hopper to fill the lower part of the carbonizer once more. This green coal, coming on to the overheated plates, causes a big rush of gas. An episode such as the above is referred to in the following pages as a slip. When the heat on the floor of the carbon-

izer is suitably graded, the coal does not reach a point where tarry vapours begin to be given off until all the coal has reached too high a temperature to allow the condensation of tar. All stickiness is thus avoided.

When trouble was experienced in these earlier runs from slips, the correct remedy was therefore at once applied: that is, the upper portion of the carbonizer was kept cooler. The results of the earlier runs fully confirmed the belief that the lignite must be treated gradually to avoid trouble from it becoming sticky: that is, the temperature of the upper plates must be graded down. It was also found that the faster the coal was travelling, the hotter it was possible to maintain the upper plates without causing slips. In this run there were slips for a while after commencing to charge green coal, but after the gas supply to the burner had been slightly reduced there was no further trouble to the end of the run. Note, by green coal in this connection is meant dried lignite in contradistinction to the carbonized lignite charged at the beginning of the run.

Run 7, August 11. — This was another single day run. After conditions became regular, the discharge was maintained at 70 pounds per hour. The temperature of the carbonizer rose steadily throughout the run. For the last two hours the discharge contained from three to four per cent of volatile matter. Analysis of a composite sample of the discharge showed 5.4% volatile matter, and 11,720 B.t.u. per pound. Operation during the run was fairly satisfactory. The gas consumption was 600 cubic feet per hour at the middle of the run, but this was later reduced somewhat.

Run 8, August 12. — A similar day's run to the above, but with the discharge speeded up to 105 pounds per hour. Analyses of the samples taken during the last three hours run varied from 5.7 to 7.4% volatile matter, and averaged 6.4%. All went fairly well.

Run 9, August 14. — A similar day's run to the above, but with a discharge of 140 pounds per hour. A small gas explosion during the operation of starting up, a minute or two after the evolution of gas began, but before all the air had been displaced, moved some of the covers. These were pushed back into position, the cracks cemented, and the run continued. The average analysis of discharge during the last two hours run was 10.3%. The average rate of charge during this period was 215 pounds per hour, and the discharge 140 pounds. This corresponds to a 65% yield.

Run 10, August 15. — As before, with 140 pounds discharge. This was not as satisfactory as the previous run. The temperature rose too high at the top of the retort, causing irregular operation. The coal charged had 8.2% moisture. The discharge was erratic, varying from 10.0 to 14.4% volatile matter. The city gas burned was about 540 cubic feet per hour.

Run 11, August 18. — This was a very windy day, and shortly after the first evolution of gas when the green coal entered the furnace there was an explosion which blew a number of covers off the carbonizer. During this period, as stated above, the gas chamber had not been divided at all. The bottom of the carbonizer was probably filled with air, and the top with gas. The leaky condition of the brickwork and the strong wind resulted in a gas-air mixture reaching some point where the temperature was high enough to ignite it, with the results cited. It might be noted that the only time when there appeared to be any danger at all was shortly after the first charging of green coal. With care this danger could be entirely eliminated.

Modifications. — Before repairing the carbonizer, certain changes were made. The simple gas pipe burner was changed to a bunsen burner, as shown in Fig. 37, in order to get a more intense heat in the lower part of the carbonizer without unduly heating the top part. The bottom four firebrick baffles, which were without satisfactory means of support, were replaced by seven cast iron baffles supported by side plates which rested on the floor. These baffles had a one-inch clearance underneath, as before; but, being closer together, gave a thinner layer of coal over the more intensely heated portion of the floor. The width of the chamber at the top was eleven inches, and at the bottom was ten and three-eights inches between the side plates of the baffles. These changes reduced the normal capacity of the carbonizer from 104 pounds to 69 pounds between the entrance to the discharge and the rod in the hopper.

Period 4. — *Run 12, August 25-26.* — This was intended to be a 30-hour run, but the supply of dry coal came to an end after only 20 hours of regular running. An attempt was made to continue with undried coal, but the carbonizer immediately choked.

Approximately 1¼ tons of dried material were carbonized. For the first four hours after operation became normal the discharge was at the rate of 70 pounds per hour, and contained 7.9% volatile matter. For the next six hours the rate was 105 pounds, with an average of 12.0% volatile matter. For the last seven hours, the rate was

140 pounds, with an average of 11.4% volatile matter. The composite sample of the charge showed 7.1% moisture. The raw coal which blocked the carbonizer when charged at the end of the run contained 22.8% moisture. The gas consumption for the last eight hours averaged 460 cubic feet per hour.

Run 13, August 29. — Tried to operate with carbonizer lowered to an inclination of 40½° on the plates, but could not get material to flow. At 42½° still had difficulty. Found an obstruction in one compartment, but even when this was removed operation was much inferior to the usual running at 45°; therefore raised carbonizer to original height. Could not raise to a steeper angle without removing the hopper, and the regularity of movement at 45° appeared as good as could be expected.

Run 14, September 2. — In this and subsequent runs a small booster was used on the gas line. This gave a steady supply of gas to the furnace in spite of fluctuations of pressure in the gas main.

This run was continued for about seven hours: four hours at a 70-pound rate, and three hours at 105-pound rate of discharge. The discharge towards the end averaged 9.5% volatile matter. The gas consumption was 475 cubic feet per hour.

Some of the discharge samples were cut in half in the riffle; one half was analyzed as usual, the other half was screened through a 10-mesh screen, and the oversize and undersize analyzed separately. The results were as follows.

	Volatile Matter, %		
Sample No.	*Regular*	*Over 10 mesh*	*Through 10 mesh*
1	7.7	9.1	7.1
2	10.0	10.7	9.8
3	11.3	15.0	11.1
4	15.5	18.4	15.3
Average	11.1	13.3	10.8

This shows that the larger pieces are not as well carbonized as the smaller ones, and suggests the advisability of leaving the material a longer time in the carbonizer in the hot bottom compartment to allow an equalization of temperature to take place. This point was considered both in the subsequent modifications of the Ottawa carbonizer and in the design of the full-sized retorts.

It should also be mentioned that it was found that if a sample of the discharge was analyzed at once and then re-analyzed next day, the repeat analysis might show as much as 2% more volatile matter than was found in the first. This presumably is due to the occlusion of air by the carbonized lignite.

Run 15, September 3. — A similar run to the previous one, with discharge rates of 70, 105 and 140 pounds per hour. No special new features observed. Had rather more difficulty than usual.

Run 16, September 4. — Commenced a similar run, but found it even more difficult than on previous day to maintain steady operation. Difficulty appeared to be located in the chambers over the lowest iron plates. Shut down the run at noon.

When the carbonizer was examined, it was found that the three lowest cast iron plates were badly buckled and burned. These warped plates had obstructed the channel, and caused the difficulties of the previous runs. It was also realized that the expansion and contraction of the iron plates in the intermittent running of these tests was largely responsible for the damage to the brickwork of the retort.

Modifications. — The three cast iron plates referred to above, which had side plates and were stepped as originally installed, were replaced by three flat cast iron plates with half-cut ends, arranged flat in continuation of the carborundum slabs. Four new cast iron baffles were used at the bottom of the retort, and these were followed by five of the old cast iron baffles. The new baffles had one-and-one-half inches clearance, and were ten inches long from baffle to baffle. This increased the capacity over the carborundum slabs 65%. The cast iron baffles were covered with firebrick, arranged loosely to allow the ready escape of the gas. This arrangement reduced the loss of heat radiated to the top of the carbonizer. It also cut down the gas space, and thus reduced explosion risk. The capacity of the modified carbonizer from hopper rod to discharge spout was about 75 pounds, instead of 69 pounds as before. The increased capacity towards the bottom was nearly counterbalanced by the reduced capacity in the middle of the carbonizer. The carbonizer as thus modified is shown in Figure 38.

Period 5. — *Run 17, September 10.* — A short day's run. Discharge alternated between 70 and 105 pounds per hour. At the faster rate the temperature of the retort fell too low. Gas consumption was 480 cubic feet per hour.

Run 18, September 11. — A short day run. Discharge rate mainly 70 pounds per hour. Temperature satisfactory. Gas consumption, 515 cubic feet per hour.

Run 19, September 12. — A short day run.

Run 20, September 15. — A fourteen-hour run. Discharge varied from a 70-pound to 140-pound rate. Gas rate, 530 cubic feet per hour. This was a very unsatisfactory run. Afterwards it was found that the gas offtakes were choked, and that one of the loose firebricks had fallen down off a baffle, almost blocking the channel. Before the next run, changed the gas offtakes to two-inch pipes, each pipe connected by a cross to a separate vertical two-and-one-half inch pipe. These vertical pipes were open at top and bottom, but the bottom end was water-sealed in a vessel which also acted as a tar collector. There were eleven of these offtake pipes.

Run 21, September 18. — A short day run. Discharge, 70 to 140 pounds per hour. Gas rate, 540 cubic feet per hour. A very windy day, but carbonizer ran fairly well and unusually smoothly.

Run 22, September 19. — A long day run. Discharge rate, 70 pounds per hour. Gas rate, 540 cubic feet per hour. Analysis of the discharge showed a high volatile matter content in the earlier part of the run, but this came down somewhat later. It averaged 13.9% volatile matter.

Run 23, September 23. — A short day run. Discharge rate, 70 pounds per hour. Gas rate, 580 cubic feet per hour. Got good temperatures in the afternoon, with a consequent drop to 10% volatile matter. Moisture in coal as charged, 6.8%.

In some of the earlier runs (for example, Run 9) the volatile matter was reduced to 10% with a discharge rate of 140 pounds. In the later runs it appeared hard to reduce to this volatile matter content with only half the discharge rate. It was thought possible that this was due to the reduction in the quantity of coal in the carbonizer, with the consequent reduction of time that any piece of coal remained in the retort.

MODIFICATIONS. — A new design of cast iron baffle was inserted. This design rested more firmly on the floor of the retort. Also some cast iron fillers were made which enabled the distance from baffle to baffle to be varied at will. As thus modified, there were ten baffles in all, instead of thirteen as before. These are shown in Figure 39. Also, a sheet of wire gauze was inserted on the top of the baffles to prevent anything falling down which would obstruct the channel. A loose firebrick cover was put on as before. The capacity, as modified, was 89 pounds from spout to hopper, an increase of 14 pounds.

Period 6. — *Runs 24 to 28, September 29 to October 3.* — Five runs were made during the week, each run from 9 a.m. to 10 or 11 p.m. The operation was fairly smooth, and no poking was required. Early in the week there were some big slips, but by Friday these had almost ceased. Some high temperatures were attained, with a white heat at the bottom of the heating flue. The lignite gas production was distinctly high.

During the first run dry lignite was carbonized, with a discharge rate of 70 pounds. The volatile matter gradually decreased from 11.6% to 5.5%. With a rate of 105 pounds, the volatile matter averaged 11.8%. The gas consumption averaged 610 cubic feet per hour. The carbonizer was unusually cold at the beginning of this day's run.

During the remainder of the week a mixture of dry coal with high-volatile-matter carbonized coal from previous runs was charged. This was done in order to obtain a large stock of thoroughly carbonized material for briquetting tests.

The top carborundum plate (a plate broken in half to fit the necessary space) and the bottom iron plate were in poor condition at the beginning, and in very bad condition at the end of the week. There was one hole completely through between the plates. The combustion flue was found to be almost blocked with broken fire-brick baffles, lignite ash, iron slag, etc. It appears that this must have been responsible for much loss of heat, the gases escaping wherever possible. The under surface of the carborundum plates was scarred by molten iron slag, but they were otherwise in good condition. The iron baffles came out in perfect condition. The iron plate referred to above had buckled to such an extent as to almost block the centre of the carbonizer channel. Also the discharge thimble at the bottom had buckled and blocked the centre of the channel.

MODIFICATIONS. — Two iron floor plates had been sent off in June to be "calorized", but these had not yet been returned. On the other hand, a full consignment of carborundum slabs had been received. These carborundum slabs were known as "Carbofrax", the earlier ones being "Refrax". It was therefore decided to reconstruct the carbonizer with "Carbofrax" slabs and iron baffles throughout. This meant the abandonment of the test of calorized iron plates which had been intended. The arrangement is shown in Figure 40. The baffles were covered with wire screen and loose firebrick covers as before. There were ten two-inch gas offtakes, and three gas chambers, as shown. The broken fire-brick baffles in the heating flue were not replaced. This shortening of the passage for the flue gases may, at least partially, account for the lower efficiency of the retort during the later runs. The iron plate forming the bottom of the feed hopper was slightly more inclined, to allow the whole carbonizer to be dropped to an angle of 51° on the plates, a change made possible by the absence of any stepped plates. The inclination of the discharge spout, which could not be readily changed, prevented a drop to 45°. The new capacity was 88 pounds, or slightly less than before. A re-calibration of the discharge wheel with carbonized lignite showed slightly over 3.8 pounds per turn, so this figure is used in some of the subsequent runs.*

Period 7. — *Runs 29 and 30, October 9 and 10.* — Two long day runs, treating a mixture of dry, partially carbonized, lignite. Operation was very smooth, but temperatures were low, and flame smoky. The gas consumption was high: over 700 cubic feet per hour. The gas consumption figures about this period, as compared with earlier figures, threw doubt on the accuracy of the gas meter. It was suspected that the suction of the gas booster has in some way damaged the meter, but no ready means was available for testing.

The gas burner was changed after Run 30 to increase the air admitted. Four one-inch air holes were drilled to supplement the existing four holes of three-quarter inch size.

Runs 31 to 34, October 14 to 17. — These runs were on successive days from 9 a.m. to 10 or 11 p.m. Had no notable trouble during the week, but again found it difficult to get a good hot flame. The first three days, treated a mixture of dry and carbonized lignite, but the fourth day treated dry lignite only, and took careful records. During this test, ran one hour at a 23-pound discharge rate, three hours at 46 pounds, five hours at 76 pounds, and five hours at 114 pounds discharge per hour. Noticed that the movement in the feed hopper did not regularly follow the movement of the discharge wheel, but found that the trouble was in the discharge chute, which, owing to the modifications introduced, was at an inclination of only 38° for part of its length. This test was noteworthy in that the moisture in the coal charged rose as high as 11 to 12% without causing trouble. The temperatures in the retort, however, were markedly depressed.

Runs 35 to 38, October 27 to 30. — Four long day runs on successive days. These runs were carried out by the laborers almost without supervision. Rate of discharge, mainly 76 pounds per hour. Operation was very satisfactory, but output low.

The day following Run 38, the meter was found to be completely out of commission, and it was replaced by a new one.

Runs 39 to 42, November 3 to 6. — Four long day runs, carried out mainly to increase stock of carbonized material. Operation satisfactory, but output again low. New meter would only pass 550 cubic feet per hour. The temperature with 520 cubic feet per hour appeared higher than with 700 cubic feet with old meter.

Run 43, November 17 to 21. — This was an 88-hour continuous run. Tests were made at intervals during the run, at four different rates of discharge. These tests were run in each case only after the carbonizer had become reasonably steady under the conditions prescribed for the test. The general diary follows.

Continuous Carbonizer Run, Nov. 17 to Nov. 21, 1919.
General Diary

Nov. 17	9.00 A.M.	Gas lit.
	1.00 P.M.	Carbonizer filled.
	1.15 P.M.	Discharge at 10 minutes commenced.
	3.00 P.M.	Discharge at 5 minutes commenced.
	6.00 P.M.	Discharge at 4 minutes commenced.
	7.00 P.M.	Carbonizer up to approximately full heat.
		Temperatures remained fairly steady through the night.

*N.B.—This value varied with the size of the coal, and also with the direction of rotation of the wheel.

Nov. 18 Weather cloudy, with occasional rain during the day.
9.18 A.M. to 4.59 P.M. *Test A run at 4-minute discharge.* Charge fed in 100 lbs. at a time, and discharge taken over same periods.
5.00 P.M. Continued run as during test.
Nov. 19 Weather fairly mild, with snow.
5.00 A.M. Turned gas full on.
6.00 A.M. Changed to 3-minute discharge.
9.05 A.M. to 5.01 P.M. *Test B run at 3-minute discharge.* Charge fed in 130 lbs. at a time, and discharge taken over same periods.
5.02 P.M. Continued run as during test.
Nov. 20 Weather clear, cold, and windy.
5.00 A.M. Changed to 2-minute discharge.
8.00 A.M. to 9.00 A.M. Changed back to 3-minute discharge whilst making some repairs and cleaning gas offtakes.
10.12 A.M. to 6.00 P.M. *Test C run at 2-minute discharge.* Charge fed in 200 lbs. at a time, and discharge taken over same periods.
6.00 P.M. Changed to 2½-minute discharge.
Nov. 20 to Nov. 21 7.15 P.M. to 12.28 A.M. *Test D run at 2½-minute discharge.* Coal fed in one bag of 165 lbs. at a time, and discharge taken over same periods. No trained observer during this test.

Very little trouble with operation during the week. Stopped only when all dried lignite was used up.

TABLE IX.

CARBONIZER RUN, *Nov. 17 to Nov. 21, 1919.*

AVERAGE TEMPERATURES, ETC., OVER THREE-HOUR PERIODS.

Date and Hour	C_1 °F.	C_4 °F.	C_8 °F.	F_9 °F.	A_2 °F.	Air Temp., °F.	Coal Temp., °F.	Gas, cub.ft., per hr.	Discharge period
Nov. 17									
12-3 P.M.	960	890	830	1,330	310	50	150	515	10
3-6	1,470	1,050	590	1,530	410	48	120	523	10-5
6-9	1,590	870	540	1,550	450	45	145	487	4
9-12	1,610	720	460	1,550	...	...	...	490	4
Nov. 18									
12-3 A.M.	1,600	760	470	1,560	...	...	...	523	4
3-6	1,600	890	480	1,570	...	...	...	523	4
6-9	1,650	860	470	1,580	540	45	120	537	4
9-12	1,640	800	430	1,600	570	42	95	520	4
12-3 P.M.	1,660	900	470	1,620	600	42	85	523	4
3-6	1,580	870	470	1,590	610	41	90	507	4
6-9	1,540	840	480	1,540	580	...	...	497	4
9-12	1,570	990	510	1,530	...	...	...	480	4
Nov. 19									
12-3 A.M.	1,570	930	530	1,530	...	...	...	513	4
3-6	1,570	1,020	550	1,540	...	...	...	506	4
6-9	1,550	990	560	1,550	...	26	...	517	3
9-12	1,420	710	530	1,550	560	28	115	527	3
12-3 P.M.	1,280	750	570	1,580	580	29	155	530	3
3-6	1,310	780	550	1,620	600	27	150	523	3
6-9	1,330	740	490	1,560	590	...	...	507	3
9-12	1,310	800	540	1,530	...	...	...	513	3
Nov. 20									
12-3 A.M.	1,250	670	510	1,500	...	...	...	520	3
3-6	1,220	730	550	1,510	...	...	...	520	3-2
6-9	1,220	710	480	1,510	550	...	...	503	2-3
9-12	1,510	620	380	1,480	560	22	75	507	2
12-3 P.M.	1,500	530	380	1,450	560	24	60	517	2
3-6	1,540*	470	380	1,440	550	25	60	503	2
6-9	1,600	590	370	1,430	530	24	...	507	2½
9-12	1,580	600	370	1,440	520	24	...	510	2½

*New fire end inserted.

Table IX gives the temperatures, gas consumption, and discharge rates averaged over three-hour periods throughout the run. The temperatures marked C-1, C-4 and C-8 are taken with the pyrometer fire ends inserted in the charge at approximately the bottom of the carbonizer and one-third and two-thirds of the way up, respectively. Temperatures F-9 were taken at the top of the heating flue, and A-2 at about two-thirds of the way down the air preheating flue. It should be noted that the temperatures of C-1, C-4 and C-8 vary widely according to the exact position of the fire end: that is, with its proximity to the strongly heated floor of the retort. The coal temperature is also uncertain.

Table X gives the average results over the test periods run. A sample was taken from each bag of coal charged, and a corresponding sample of the discharge. These were analyzed separately for moisture and volatile matter. Composite samples were also prepared for each test period, and these were more fully analyzed. The analyses in this table are the averages of the separate samples.

The yields, especially at low rates, are uncertain, due to possible difference in content of retort and spout at beginning and end of test. The yield for Test B is apparently too low. There are also marked discrepancies in the analyses for this test. The duty rates noted are the pounds of coal charged per 24 hours per square foot of effective floor area. The width of floor between the baffle walls was 10¾ inches, and the heated floor length almost 9 feet, giving an area of approximately 8 square feet.

Table XI gives the analyses of the composite samples of charge and discharge during the test periods.

TABLE X.

AVERAGED RESULTS THROUGH TEST PERIODS.

Date.....November	18	19	20-21	20
Test.....	A	B	D	C
Discharge period.....minutes	4	3	2½	2
Duration of test.....hours	7.7	7.9	5.2	7.8
Gas consumption.....c.f. per hr.	517	523	508	510
Gas consumption.....c.f. per lb. of discharge	10	7.6	6.0	4.9
Coal charged:				
Weight, moist as charged.....lbs. per hr.	91	115	126	154
Weight, dry basis.....lbs. per hr.	78	108	114	137
Duty rate.....	270	345	375	460
Moisture content.....%	13.8	5.6	9.7	10.7
Carbonized residue:				
Weight.....lbs. per hr.	51.8	68.7	84.7	104.8
Weight per 1″ width of retort.....lbs. per hr.	4.8	6.4	7.9	9.8
Yield, from coal as charged.....%	56.9	59.9	67.2	68.0
Yield, from dry coal.....%	66.1	63.4	74.3	76.2
Volatile matter content.....%	5.1	7.0	16.3	18.1
Temperatures:				
Air.....°F.	42	28	24	24
Coal in feed hopper.....°F.	93	140	..	60
Air preheating flue.....°F.	590	577	525	552
Heating flue, at top.....°F.	1,605	1,580	1,440	1,450
Coal in retort, at ⅓down.....°F.	455	550	370	385
Coal in retort, at ⅔down.....°F.	850	750	595	535
Coal in retort, at bottom.....°F.	1,630	1,350	1,595	1,520

TABLE XI.

Analyses of Composite Samples of Charge and Discharge.

Test Period	A		B	
	Charge	Discharge	Charge	Discharge
Moisture.........%	13.7	....	5.1	....
Ash.........%	13.2	22.7	15.1	21.2
Volatile matter.........%	32.4	6.5	38.2	11.1
Fixed carbon.........%	40.7	70.8	41.6	67.7
Fuel ratio.........	1.25	10.9	1.25	6.1
Calorific value.........B.t.u. per lb.	8,930	11,180	8,940	11,140

Test Period	D		C	
	Charge	Discharge	Charge	Discharge
Moisture.........%	9.7	....	10.7	....
Ash.........%	13.5	19.6	13.6	19.6
Volatile matter.........%	34.4	17.8	34.0	18.6
Fixed carbon.........%	42.4	62.6	41.7	61.8
Fuel ratio.........	1.25	3.5	1.25	3.3
Calorific value.........B.t.u. per lb.	9,390	11,050	9.200	11,100

Summary and Conclusions of Tests with Ottawa Carbonizer.

The tests with this carbonizer were taken as proving that the basic design was both workable and satisfactory; that partially dried lignite could be carbonized to any desired extent; and that it could be made to flow steadily down through the retort by means of its own weight, controlled only by the discharge mechanism at the bottom. The tests, however, also showed that the actual construction of this carbonizer was unsatisfactory in many ways, but principally because it could not be maintained gas-tight.

It was considered probable that an increase in the length of the retort, with a corresponding increase in the velocity of the coal, would tend towards smoothness of operation rather than the reverse. It also seemed certain that a very marked increase of efficiency could be obtained with a wider retort, where radiation loss would be relatively small.

It was obvious that this retort could not be operated with the gas produced from it, even if the brickwork had been tight enough to allow this to be collected; but it did not seem hopeless to expect that the contrary might be the case in the larger and better constructed carbonizer, built later at Bienfait. (See Figs. 41 and 42).

Cast iron was shown to be unsatisfactory as a floor material, but carborundum plates appeared to be suitable. The cast iron baffles, on the contrary, worked well and stood the heat. The carbonized lignite was sometimes found to have a higher ash and lower calorific value than might be expected; but with leaky brickwork some combustion of the charge on windy days was almost inevitable.

No information could be obtained either as to the yield or analysis of the gas and tar produced. For this information the earlier work has to be consulted, or the results obtained with the laboratory model retorts.

APPENDIX 19

The Lignite area of Southern Saskatchewan.

By A. MACLEAN.

The work begun in this area in August of 1917 was continued during the present season. Owing to the lack of student assistants it became necessary to ask J. H. Lill, who for the past three years has been camp assistant, to act as field assistant as well. It is a pleasure to record the high efficiency of Mr. Lill in this capacity.

The field to be covered by the work extends from the Manitoba — Saskatchewan boundary to Range 21, W. 2nd. Meridian, and from the International boundary on the south, northward to the north side of the eighth row of townships. In the western part of this area the topography is characterized by the hilly front of the Missouri Couteau and the broken and irregular uplands to the southwest of it. From the foot of the couteau the country slopes gently to the eastward falling from an elevation of 2339 at Ceylon (twp. 6, range 20, W. 2nd.) to 2028′ at Webster (twp. 5, R. 16, W. 2nd.) to 1870′ at Estevan, (twp. 2, R. 8, W. 2nd.), and 1610′ at Gainsborough near the Manitoba boundary. This part is deeply dissected by the valley of the Souris, and in the region adjacent to it, by the valleys of its tributaries, Long Creek, Short Creek and Moose Mountain Creek.

The best exposures are in the vicinity of Estevan, and from here down the river to beyond Roche Percee. Other exposures are to be found in the neighborhood of Halbrite and in the valleys of the Missouri Couteau region. For other parts of the field it is necessary to depend on the records of drill holes. For access to these the writer returns thanks to the well drillers. farmers, and prospectors of the district. It was hoped to work out a type section in the region of the best exposures (Estevan and Roche Percee) and with the aid of this section to catalogue the rock of the limited and isolated exposures in other parts of the area. This seems to be the only plan feasible but it is attended with considerable difficulty. The rocks, sands, clays and lignites are of shore formation origin, and as is common with this type of deposit the lateral variation is considerable, so that correlation through the criteria of physical characteristics is open to question. Fossils are very scarce and even when present it is to be remembered that the present lateral variation in the rock is but one expression of the original variation in conditions which would have their effect on the fauna as well as on the disposition of the time. An attempt to compile a composite section (subject to subsequent revision) of the eastern part of the district gives the following arrangement.

COMPOSITE SECTION, SOUTH SASKATCHEWAN LIGNITE FIELDS.

	ROCK	Thickness	Depth	Elevation
				1,886
A.	Till	6	6	1,880
B.	Dark brownish green colloidal clay with a little silt, weathering to a coarse nodular mud, showing on exposure surface no sign of bedding	10	16	1,870
C1.	Lighter colored colloidal silt, with bedding well marked by reddish colored laminae or bands. This color is also often expressed in streaks and flashes	6	22	1,864
	Lignite seam (2″)			
C2.	As C1. but lighter in color and with laminae better marked. Colloidal at the top and bottom, but less so in the middle. At the base is a hardened calcareous concretionary band and a 2″ seam of lignite	8	30	1,856
D.	Silt or non-colloidal sandy clay, lighter in color than C. and with laminae better marked. At base is a calcareous clay ironstone, forming in weathered exposures a shelf above the next beds below. Near Roche Percee these beds are more massive, the sand coarser, and the color present in flashes rather than along the laminae. In all cases observed this bed carries a number of clam shells (sp. indet) at about 5′ from the base	15	45	1,841
E.	Light grey sandy clay, darker and colloidal at the base and top, less so in the middle. At the base is a six inch seam of lignite	25	70	1,816
F.	Grey, very fine grained, non-colloidal clay, with a ten inch seam of lignite at the base	7	77	1,809
G.	Sand, buff in color, massive in structure, often cemented to form a sandstone which breaks from exposure faces in large columnar blocks	15	92	1,794
H.	Lignite with bands of clay	2		
	Grey colloidal clay	3		
	LIGNITE (First workable seam)	5	102	1,784
	The above section is taken from an exposure in middle of north side of section 11, twp. 1, range 7, W. 2nd. The following section in continuation of the above is from and exposure in the north half of section 24, twp., 1, range 7, W. 2nd. (2 miles north and 1 mile cast of the former location)			
H.	LIGNITE (as above)	5	67	1,795
I.	Fine grained clay, 6″ to 1′	1	68	1,794
	Yellow ochreous sand and white, fine grained non-colloidal clay	13		
	Lignite band, 2″			
	Sandy non-colloidal clay or silt	3	84	1,778
J.	LIGNITE (second workable seam)	4	88	1,774
K.	Sand to base of the exposure	3	91	1,771

(COMPOSITE SECTION *Continued*)

	ROCK	Thickness	Depth	Elevation
	The continuation of the section may be taken from the log of the bore hole of the Souris Valley Oilfields Co. The well was located ½ mile south of the above exposure, and was started in the valley at an elevation of 1780′. Starting at the second seam of lignite section is:			
J.	LIGNITE (second workable seam)	4	11	1,769
K.	Blue grey clay mixed with sand getting darker toward the base	21	32	1,746
L.	LIGNITE of good quality, (third workable seam)	6	38	1,742
M.	Dark grey clay	5	43	1,737
M.	Below this are clays and sands to bottom of bore hole at 236′	193	236	1,544
	As provisionally correlated with the exposures and well record near Estevan (at section 17, twp. 2, range 7, W. 2nd.) Elevation at surface 1,890, the continuation from the lignite seam at J (second workable seam of the district) is:			
J.	LIGNITE. (second workable seam of district; the upper Estevan and Bienfait seams), 7′ to 10′	10	47	1,843
K.	Heavy colloidal sandy clays with some small lignitic bands	35	82	1,808
L.	LIGNITE, interbanded with stiff clays, the workable lignite varying from 3½′ to 12′ and upward. (The third workable seam of the district, the lower Estevan and Bienfait seam and the main Bienfait and Taylorton seam)	15	97	1,793
M.	Heavy dark very colloidal clay	4	101	1,789
N.	Light colored sandy clay	77	178	1,712
O.	Very coarses and containing a high percentage of quartz, cemented to a very compact mass by a small amount of colloidal clay	46	224	1,666
P.	Clay	5	229	1,661
Q.	LIGNITE	2	231	1,651
	Several wells have continued below this lower coal "Q". The section as continued is taken from the log of the borehole at Taylorton (S.W. ¼ section 4, twp. 2, range 6, W. 2nd. Elevation of top of hole, 1,860)			
Q.	LIGNITE	3	203	1,657
H.	Grey sands	97	300	1,560
S.	Mostly grey clays with some sand in lower 30′	110	410	1,450
T.	LIGNITE, of very good quality 4′2″ thick	4	414	1,446
U.	Light blue clay with a few sand streaks, eighteen inches of lignite occur near the middle	180	594	1,266
V.	Lignite, soft	2	596	1,264
W.	Grey clays and sands	27	623	1,237
X.	LIGNITE of very good quality	4	627	1,233
Y.	Blue clays and sands	186	813	1,047
Z.	Soft shales, said to become harder with depth	37	850	1,010
	This represents the bottom of the section as obtained from this well. From a well drilled about 16 miles north of Estevan, Mr. Maley reports that this shale continues for at least 500′ becoming harder with depth. If it is the same shale as at Taylorton, then at the latter place it would extend to at least			550

The shales at the bottom of the section are described as being very much like slate — which description accords with the character of the Odanah shales of the Pierre. They are for the present considered as Pierre, representing the Upper Odanah. It is as yet undecided where the limits of the upper Pierre — the Fox Hills Sandstone, lie in the section. So far no exposure of these has been found in the area, although they may occur in the northern part of the field.

On exposure surfaces the beds may show a dip of two or three degrees in any direction. These minor fluctuations are to be found in any part of the field so far examined, while South of Neptune the dip is much higher, and near Halbrite reaches to fifteen degrees, forty-five degrees and even ninety degrees. Near the larger stream valleys part of this dip may be due to slipping and differential subsidence, but the occurrence of these rolls at points distant from the streams leads to the belief that there has been a decided disturbance over the area. In the Estevan and Roche Percee part of the field the general dip is towards the southeast. To the east of this an elevation toward the north seems to make itself felt and the dip is more southerly.

In the section given previously it is to be noted that there are three workable seams available in the Estevan, Roche Percee and Bienfait district. At a depth of about two hundred feet there sometimes occurs a smaller seam two or three feet thick. At about four hundred feet there is a seam, fairly constant, four feet thick, while between six hundred and seven hundred feet occurs another seam four feet thick. These two lower seams are said to analyze higher in fixed carbon than the upper seams.

The greater amount of the lignite mining is done within a radius of fifteen miles of Estevan and in the southeast quarter of this area. In addition to this lignite seams are worked at present in the Gladmar district (Twp. 3, Range 19, W. 2nd.) and in the Neptune district (Twp 4, Range 16, W. 2nd.). Lignite mining was attempted at Halbrite but the shattered condition of the seam together with its high dip made mining unprofitable. No attempt is made at present to correlate the Gladmar, Neptune, or Halbrite seams with any of the others. The notes on the following condensed section indicate the tentative correlation of the seams in the Estevan, — Bienfait — Roche Percee fields. It is to be understood that the seams are not continuous through the whole area. In some cases they split up, or pinch out completely, to start in again at some distance from the last observed occurrence. In other cases the seams have been removed by erosion. This is true of the upper seam at Estevan, and of both upper seams at the Hawkinson mine to the west of Bienfait. In the Roche Percee district and along Short Creek it would appear that all three seams are represented. The condensed section is as follows:—

No.	ROCK	Thickness	Depth	Remarks
1.	Colloidal sandy clays, with some non-colloidal clays and silts. Includes some small lignite bands and ends at base in a 15′ band of buff sandstone.....	97	97	Occurs only south of the river along Short Creek. N. W. of this removed by erosion.
2.	LIGNITE. The first workable seam. This is marked as "H" in the extended section........	5	102	Occurs only in Roche Percee district. Eroded at Estevan.
3.	Sand and silt, 16′ to 20′........................	20	122	
4.	LIGNITE. The second workable seam. Marked as "J" of extended section..................	4	126	Upper Estevan seam. Eroded in part near Bienfait.
5.	Stiff blue grey clay or in some cases incoherent sand, 20′ to 50′............................	25	151	
6.	LIGNITE. The third workable seam. Marked as "L" of other section........................	6	151	Wooloomooloo, Anderson, Shand & Bienfait - Taylorton seam.
7.	Dark grey clays and sands......................	130	287	
8.	LIGNITE. "Q" of extended section..............	2	289	
9.	Sands and clays............................	207	496	
10.	LIGNITE. "T" of extended section..............	4	500	
11.	Clays and sands with streaks of lignite..........	209	709	
12.	LIGNITE. "X" of extended section..............	4	713	
13.	Blue clays and sands..........................	186	899	
14.	Shales, extending to a depth of at least 500′......			Probably the *Odanah* of the Pierre.

If the correlation suggested be correct then the third workable seam is the most productive of the district. Unfortunately near Estevan it is badly split up, there being three beds of clay, totalling 5′ separating four seams of coal, totalling, 7.5′. The lowest of these 3.5′ thick, is the one worked at the Wooloomooloo mine, just outside of Estevan. At the Anderson mine 5 miles to the southwest of the Wooloomooloo the clay partings have disappeared and there is 12′ of workable coal. At the Shand mine the seam is 9′ thick, and at Taylorton 7′, increasing toward the north to 15′ and upward at Bienfait. South of the river near Roche Percee this seam has been reported by Mr. E. Pierce but it has not been worked. With the exception of the Wooloomooloo all the mines at Estevan are at present operating on the second seam (No. 4 condensed section). The top seam No. 2 of section, is worked at Roche Percee and along Short Creek.

Of the three lower seams those marked 10 and 12 are more probable to be of importance. The first, as analyzed for Mr. Symons of the Western Dominion Collieries showed a fixed carbon content of 42% and the lowest a fixed carbon content 48% to 51%. Although marked at 500′ feet *in the section*, the first of these two lower seams generally occurs in well borings somewhere in the neighborhood of 400′ to 450′. It is reported by Mr. Livengood at Torquay at 427′, and at a point a few miles north-east of Estevan at 400′. Mr. Darling located it at near 400′ in the vicinity of Tableland and Mr. Symons reports it in the Taylorton bore hole at 409′. Mr. Peterson gives the depth of the lowest seam at Estevan as 600′ while at Taylorton it occurs at 623′. These two seams appear to be fairly consistent in their occurrence over a wide area, and the lignite is probably better than the upper seams, but, at present the depth at which they occur would prevent their being operated in competition with the lignite beds nearer the surface. The two or three foot seam ("Q" & "8" of the two sections respectively) recurs fairly consistently in bore holes at a depth of 200′ to 250′. Near Estevan it is reported by Mr. Maley at 231′. It is not at present important except for the possibility of its increasing thickness, or being linked up with another seam, in some other part of the field.

The lignite at Halbrite has not been located in the section. The clays and lignite here have been subjected to pronounced folding and crumpling — to which, of course, the clays have been most yielded. The lignite has been badly shattered so that it mines as a very dirty seam and wherever prospected carries the undesirable features generally associated with "outcrop" coal. This lignite however is probably higher in fixed carbon than that of the undisturbed seams. The features noted of the Halbrite lignite are to a large measure characteristic of the seams worked near Neptune by Wm. Ewing, (S. E. ¼ Sec. 22, twp. 4, R. 16 W. 2nd) and Wm Dee just west of the above. In this district there appear to be three seams, — the first, covered by sand is 4.5′ thick. Under this is 15′ of clay which lies above the next seam 4′ thick, while below this under 25′ of clay is the third coal seam. All the seams are rather steeply inclined and the lignite shows signs of being disturbed and shattered. As a result its mining results in the production of an excessively high percentage of slack, which under present circumstances is a complete waste. The lignite is probably fairly high in fixed carbon as compared with the undisturbed seams. This feature together with the possibility af saving the slack, now wasted, is a factor that should be considered in the search for raw lignite for briquetting plants.

Near Gladmar two mines are operated, — one by H. Slater and one by Eidsness Bros. The former is located in N. ½, L. S. 6, Sec. 11, twp. 3, R. 19 W. 2nd. The output is about 1,000 tons per year. The mine of Eidsness Bros. is located in L. S. 3, Sec. 11, twp. 3, R. 19, W. 2nd. and has an output of 3,000 to 3,500 tons per year. The output of both mines goes to supply the local demands of the district being teamed from the mine mouth for considerable distances.

The area supplied with fuel from the Estevan — Bienfait district is practically confined to Manitoba and Saskatchewan, extending from Moose Jaw and Regina to Winnipeg. A very small amount may cross the boundary to the settlers in North Dakota and Montana in the districts contiguous to the producing or distributing points on the Canadian side. The fuel is used in the area indicated for domestic and power producing purposes. For the former the lignite is generally delivered as screened lump and for the latter as, run of mine, screened lump, nut, pea, and slack. The disposition of the latter presents a problem which is worthy of consideration. In the process of mining the production of slack varies from 6% in the larger and better equipped mines to 25% in the smaller mines. This is even higher in the mines where the lignite is shattered. At the present time a very small amount of the slack is shipped but the greater portion, practically all, is shovelled back in the old workings, dumped in any required fills, or scattered over the field, where, through the possibility of spontaneous combustion, it becomes a potential menace to the mining plant or the community. When briquetting becomes an accomplished commercial process this slack can

all be utilized but at the present time much more slack is produced than can be disposed of. There is a possibility that lignite might be disposed of to larger power producing factories as a powdered fuel if a plant were devised for the satisfactory handling of it. In such a plant a large percentage of the slack could be used.

The price of lignite at the mine mouth is from $1.75 to $2.00 per ton, for screened lump. This is delivered to the consumer in Winnipeg at from $5.50 to $6.00 per ton, — as compared with Drumheller or Lethbridge coal at $9.50 to $10.50 and hard coal at $12.50. It is not yet known at what price briquettes made from the Saskatchewan lignites could be profitably delivered at the larger centres, but the possibility of making their manufacture a continuous operation throughout the year should cut down the spread that now exists between the apparent cost of production of lignite and the price of its delivery to the consumer. At present the difficulty in handling and storing the raw material, except in winter, makes it impossible to start large deliveries for future use before the beginning of October. This means that at the mines a large equipment is required to handle the heavy production demanded in the winter months. During the remaining half year the plant, and the investment represented, are comparatively idle but still remain as a charge on the coal recovered during the other half year. It is to be noted in addition that winter deliveries cannot begin until the time when the demand for freight carriers for the movement of the grain crop is so insistent that no surplus coal can be handled and hence no reserve of this fuel can be accumulated at points of retail distribution. As a result the districts dependent on it are at the mercy of whatever circumstances an uncertain winter season may impose on freight movement. Consequently, not only for the conservation of much of the lignite now wasted, and for the efficient utilization of labor and transportation systems in the summer season, but also for the protection of the constantly increasing population dependent on this fuel, it is highly desirable that not only should some scheme for better utilizing it be sought and found, but it should be put into practical operation with the least possible delay.

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APPENDIX 20

Estevan Coal Field.

Description of samples taken by A. McLean for Lignite Utilization Board, 1918.

Sample No.	MINE	As received, Moisture	Ash	Ash dried at 220° F.
1425	Wooloomooloo Mine, (McNeil & Rooks) Estevan, lower Estevan seam, 65′ from outcrop..........	36.0%	9.8%	15.3%
1426	Estevan Coal & Brick Co., Estevan, Upper Estevan seam, 300′ from S. W. corner.............	37.0	8.4	13.4
1427	T. D. Munro's mine, Estevan, upper Estevan seam, 150′ N. and 50′ E. of mine head........	36.5	7.5	11.7
1428	White Hope mine, (L. Bourquin) upper Estevan seam, old surface 150′ from mine head.........	36.5	7.8	12.3
1429	Geo. Parkinson's mine, Estevan, upper Estevan seam....................................	34.5	11.4	17.4
1430	Hans Peterson's mine, (formerly Thos. Bastien's) Estevan, upper Estevan seam...............	33.8	12.1	18.2
1431	H. Nicholson's mine, Estevan, upper Estevan seam, 300′ from mine head..................	34.6	9.4	14.4
1432	N. Anderson's mine, Estevan, lower Estevan seam, 200′ S. and 75′ E. of mine head...............	34.3	9.7	14.7
1433	Paul Underfinger's mine, Shand, upper Estevan seam, 150′ N. of face in hill..................	35.6	7.0	11.0
1434	Sask. Coal, Brick & Power Co., Shand, lower Estevan or Taylorton seam, S.W. workings, 300′ S. and 360′ W. of head frame..................	35.7	7.6	11.7
1435	Same, W. workings, 1800′ W. of head frame.......	35.3	7.5	11.6
1436	Souris Valley Colliery, (E. Siddal) Roche Percee, marked "Short Creek"......................	34.5	4.9	7.5
1437	Man. & Sask. Coal Co., Bienfait, Bienfait-Taylorton seam, E. side of workings, 600′ S. and 800′ E. of tipple................................	36.1	6.9	10.8
1438	Same, 1,000′ S. and 900′ W. of tipple..........	35.1	7.0	10.8
1439	Western Dom. Collieries, Ltd., Bienfait-Taylorton seam, Bienfait, W. entry 750′ W. of mine head...	34.4	6.8	10.4
1440	Same, E. entry, 1,000′ E. of mine head..........	36.3	6.3	9.9
1441	Sask. Coal Co., Ltd., Roche Percee, upper seam, W. entry, 400′ from mine head..............	33.7	6.3	9.4
1442	Thistle Mine, (J. A. Auld), Roche Percee, upper seam, entry, 600′ from mine head. Mine closed	34.2	5.8	8.8
1443	Interprov. Coal Co., Ltd., Roche Percee, 2nd seam from top, 300′ from mine head................	33.1	10.1	15.1
1444	Same, seam below that now mined, test tunnel, 700′ E. of mine head, 25′ in tunnel............	31.4	10.4	15.1

APPENDIX 20 (*Continued*)

Sample No.	MINE	As received, Moisture	Ash	Ash dried at 220° F.
1445	Duncan Campbell's mine, Roche Percee, main entry, 300′ from mine head	34.5	5.3	8.0
1446	Bienfait mine, Bienfait, Bienfait-Taylorton seam, 450′ N. and 850′ W. of tipple	36.3	5.2	8.2
1447	Same, 1,500′ S. and 600′ E. of tipple	37.6	5.7	9.1
1448	Bienfait Commercial Co., Ltd., Bienfait, Bienfait-Taylorton seam, 240′ S. and 200′ E. of mine head	37.7	5.3	8.4
1449	Crescent Col. Co., Ltd., Bienfait, Bienfait-Taylorton seam, 180′E. and 100′ S. of mine head	36.1	5.5	8.6
1450	Excelsior Coal Co., Ltd., Pinto, air shaft entry, 75′ from mine head	35.5	5.5	8.5
1451	Riverside mine, (A. Wilson), Taylorton, Bienfait-Taylorton seam, 400′ from face of hill	34.7	6.5	10.0
1452	W. Bowman's mine, Short Creek Roche Percee	34.0	5.0	7.6
1453	W. R. Armstrong's property, outcrop, 4′ from surface vertically and 50′ horizontally	37.0	5.3	8.4
1454	Wee McGregor mine, 2nd seam from top, Mine closed	28.7	16.6	23.3
1455	W. E. Price's mine, Roche Percee, upper seam, 350′ from mine head	34.3	6.5	9.9
1461	Slack from Manitoba & Sask. mine, sample taken by Stansfield	32.9	12.1	18.1

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APPENDIX No. 21

RECOMMENDATIONS TO THE CHAIRMAN RE SITE OF PROPOSED PLANT

Factors Affecting the Situation.

The following are the factors affecting the selection of the proposed plant:

I. — Capacity of adjacent mines to supply raw material of proper quality for an extended period.
II. — Water supply.
III. — Cheapness of raw material.
IV. — Quality of underlying lignite in case Board might find it necessary to develop its own mine.
V. — Cheapness in shipping product to operating railway.
VI. — Drainage.
VII. — Problems of housing staff.

DISCUSSION:

(I) *Capacity of adjacent mines to supply raw material of proper quality for an extended period:* The capacity of the principal mines, the product of which is satisfactory to us, is as given in accompanying table. Opposite each mine will be found also the percentage moisture content as mined, and percentage ash content when reduced to a *dry* basis.
From this table, it will be observed that the two principal mines are the Western Dominion Collieries and the Manitoba and Saskatchewan Coal Co., either of which is satisfactory from our point of view. Owing to the size of these mines, it is probable that the Board will not have to undertake any mining operations on its own account.

(II) *Water Supply:* From analyses, we know that the water of the Souris River will be satisfactory for all our purposes; hence, other factors being equal, it is cheapest to obtain water from the river. The two above-mentioned companies (the M. & S., and the W. D. C.) already have in operation a pipeline and pumping unit, which are more than sufficient for their needs. We understand also from Senator Watson, that they will be willing to come to some arrangement to sell us water. Actual rates could be discussed at a later date.
If the plant were located at any other point than in the immediate vicinity of the pipeline, it would become necessary to either go to heavy expense to put in a special pipeline, or to use well water with the prospect of having to drill extra wells. See map Figure 4.. To date, the analyses of well waters show that these are not so suitable to our needs as the Souris River.

(III) *Cheapness of raw material:* There are only three methods of getting raw material for our plant:
(a) — Mining ourselves.
(b) — Purchasing coal from immediate vicinity with delivery by mine cars or lorries.
(c) — Deliver all material from mines located at a distance, by means of freight shipments.

(a) The Board should commence mining operations only as a last resort, — in the event of business conditions arising which compel us to adopt this method.

(b) The purchase of either slack or run-of-mine lignite from existing collieries in the immediate vicinity will undoubtedly give us the cheapest coal, for the reason that we avoid excess handling charges and expensive freight shipments (especially in view of the fact that about 35% of the charges would be incurred in shipping water).

(c) While this method is a possibility, it will prove very expensive. For example: To ship lignite from Bienfait to Estevan would involve an initial charge of 80c a ton (straight freight charges) which, after allowing for presence of moisture would represent from $1.25 to $1.50 preliminary fixed charges on the finished briquette. If, in addition to this, the charge for moving lignite from Taylorton to Bienfait be included, it would make the figures even worse. In view of the foregoing, it will be seen that it is practically essential, for the success of our project, to purchase our raw material free of shipping charges.

(IV) *Quality of underlying lignite in case Board found it necessary to develop its own mine:* The lignite throughout the Estevan area is too high in ash to be even considered as a source of raw material. In the Souris region, the only mines that are suitable from this point of view are those already listed, and it will be noted that these mines all lie at the easterly end of the field, that is to say, in the region of Bienfait, Shand, Roche Percee, Taylorton and Pinto. The Board feels that the site should be located in such a manner that, if through business jealousy or for other reasons it became impossible to get slack at a reasonable figure, they could immediately start to operate their own mine. In view of the foregoing discussion on shipping, it will be seen that it is not feasible to have the mine at one spot and the plant at another hence the plant must be located over a seam with a low ash content, and the location must be so chosen that other benefits, such as water supply, shipping etc., are all safeguarded.

(V) *Cheapness in shipping product to operating Railway:* If the plant be located on any of the operating railways, the only expense will be the overhead, interest etc., on the building of a short siding, plus switching costs. If, on the other hand, the plant is not located beside an existing railway, we must either pay for the erection of a long spur, plus cost of switching by our own locomotives, or pay the switching charges of the companies who now operate private spurs. We are informed by Mr. Lanigan, F. T. M. of the C. P. R. that the present charges between the Manitoba and Saskatchewan Coal Co., and Bienfait, and between the Western Dominion Collieries and Bienfait are about $2.50 per car. These two private spurs are operated jointly by the two mentioned companies, and it would be probably possible for the Board to come to an arrangement to have their locomotive move our cars over these lines, especially in view of the fact that we shall be purchasing material from them if the Board adopt the present recommendation re site.

(VI) *Drainage:* The drainage factor is one that can hardly be discussed indetail until the actual site has been chosen. A great deal will depend on the elevation of the ground etc. etc. The problem before us is to dispose of a small quantity of effluent from the toilets in the office building and plant, a small quantity of liquid discharges from the laboratory, and a much larger quantity of clean water used for cooling purposes.

(VII) *Problems of housing staff:* These problems are serious, and in the long run may compel the Board to spend a considerable amount of money in construction of houses, bungalows, and perhaps a small club, depending upon the character of the staff. It is to be noted, however, that these problems would have to be faced at any site, except possibly in Estevan itself. However, Mr. Lanigan, of the C. P. R. informs us that Estevan itself is not overbuilt and it would only be possible to obtain houses in Estevan by ousting present tenants.

TABLE 1

List of Mines Producing Lignite of Quality Satisfactory to the Board

MINE	Location	Moisture	Ash on dry basis	For total 1915	Output, add 25% merchantable coal 1916	1917	1918
Bienfait Commercial Co., W.-J. Hawkinson, manager.....	23-2-7	37.7%	8.4%	......	......	....	19,261
Bienfait Mine, (Hosmer)......	19-2-6	36.3	8.2	41,040	57,306	77,393	65,922
L. Hamilton & R. J. Hassard, lessees....................	.....	37.6	9.1	......	......	....	....
Manitoba & Saskatchewan.... Coal Co., Ltd. .... Wm. Addie, manager.........	10-2-6	36.1 35.1 (Slack) 32.9	10.8 10.8 18.1	63,584	71,828	76,259	75,369
Western Dominion Collieries Ltd., Andrew Millar, manager.....................	3-2-6	34.4 36.3	10.4 9.9	88,500	91,200	113,214	104,834
Riverside Mine, A. Wilson, owner..................	34-1-6	34.7	10.0	......	2,846	3,717	•1,389
Excelsior Coal Co., Ltd.......	30-1-5	35.5	8.5	......	......	....	434
Souris Valley Colliery E. Siddal, owner,................	24-1-7	34.5	7.5	......	789	540	945
W. E. Prices, Mine,..........	19-1-6	34.3	9.9	......	......	....	....
Saskatchewan Colliery Co., Ltd., J. E. Price...........	29-1-6	33.7	9.4	......	......	420	2,600
Thistle Mine, J. A. Auld owner,	29-1-7	34.2	8.8	......	......	1,242	391
William Bowman,............	25-1-7	34.0	7.6	......	......	....	....
W. F. Armstrong............	" "	37.0	8.4	......	......	....	....
Duncan Campbell,...........	" "	34.5	8.0	......	......	....	....
Crescent Collieries, Ltd. J. R. Brodie, manager...........	29-2-6	36.1	8.6	......	......	....	398

Outputs are given in tons of 2,000 lbs.
•This mine has been closed since March, 1918.

DEFINITE RECOMMENDATIONS:

The staff, after a thorough consideration of the whole problem recommends that the Lignite Utilization Board, purchase or otherwise acquire a site somewhere in the northern half of section 3, Township 2, Range 6. The size should be at least twenty (20) acres. The advantages of this site are:

(a) — It is over excellent coal.

(b) — It lies half way between the two largest operating companies, and a spur siding could be run to each.

(c) — It is in close proximity to the pipeline now supplying water to the Western Dominion Collieries and the Manitoba and Saskatchewan Coal Co.

(d) — The only shipping charge to get the product on to the operating railway at Bienfait (the C. N. or C. P.) is $2.50 per car on either of the private lines. (Figure supplied by Lanigan from memory). It is to be noted in this connection that this charge is on an all coal basis, nothing being paid to ship moisture.

(e) — Drainage in this Section will probably be simple owing to the height that the land lies above the Souris River.

The disadvantages of the site are:

(a) — The lack of hotel accommodation and other usual troubles occurring in an isolated place.

(b) — No houses are available for the senior members of the operating staff, such as Manager, Superintendent, etc.

(*Sgd*) R. deL. FRENCH
(*Sgd*) E. STANSFIELD
(*Sgd*) LESSLIE R. THOMSON

MONTREAL, *Oct. 1st, 1919.*

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APPENDIX No. 22

Description of the Plant

By R. A. STRONG and I. F. ROCHE.

The Order-in-Council creating the Lignite Utilization Board defined as its objective the commercial demonstration of a process for the carbonization and briquetting of Canadian lignites. Such a demonstration naturally involves the construction of a plant sufficiently large to collect accurate data as to costs, maintenance and repairs on machinery, and such other information necessary for establishing an industry.

With this end in view the Board erected a plant, sufficiently large to turn out 100 tons of briquettes per day, 3-½ miles from the town of Bienfait, Sask., in the heart of the Souris field. The development of this district is, as yet, not very extensive, and all the large mines are within a radius of 4 miles of the location selected by the Board. Fig. 4 shows the location of the plant in respect to all the operating mines, and in addition gives a great deal of information on water supply, land levels, mining leases, etc., as existing in 1919. As will be noted, the site, which comprises 20 acres of ground, is midway between the Western Dominion Collieries and the Manitoba & Saskatchewan Coal Company, the two largest producing mines in the field.

In order to give railway connection to the plant one of these mines has constructed a spur and the other is under contract to do so when the plant is on an operating basis. Each of these mines — the M. & S. Co. and the W. D. C. —, has a railway spur to Bienfait, and thus by means of the present connection and the existing railway trackage at Bienfait, the L.U.B. plant has connection will all the other mines in the district so that coal may be purchased from any or all of them.

The following description of the plant and its operation is made in order to record permanently the facts regarding the original installation, as designed and erected in 1920 — 1921. In other appendices will be found references to subsequent changes. The description will be given under the following heads:—

(a) General Layout.
(*b*) Type of Construction.
(*c*) Raw Lignite Handling Equipment.
(*d*) Drying Equipment.
(*e*) Carbonizing and gas purification Equipment
(*f*) Mixing and Briquetting Equipment.
(*g*) Storage and Loading.
(*h*) Power House.
(*i*) Water Supply.
(*j*) Sewage Disposal.
(*k*) Office Building.

(a) GENERAL LAYOUT

The plot of ground on which the plant is built comprises 20 acres, secured by lease from the Western Dominion Collieries. The reasons for leasing rather than an outright purchase are fully discussed in Section III of the Secretary's report. A reference to the data map in Fig. 4 shows that the land in this particular locality is decidedly flat which makes drainage a difficult problem. It is also without protection from wind and fire, and it was, therefore, necessary for the Board to provide a system for water disposal and adequate fire protection. To protect the buildings from drifting snow in the winter months a wind break of trees has been planted on the west side of the stite.

The plant itself consists of a dryer building, a retort house, and a briquetting room; a power house, a building for office and laboratories, a briquette storage bin, storage tanks for tar, water supply reservoir and elevated tank, sewage and water disposal system, a binder unloading shed, and a shed over the track hopper — together with trackage in the yard for the storage and moving of cars. The general layout is shewn in Fig. 20.

The process consists of crushing and storing the raw lignite, drying it in preparation for the retorts, carbonizing and briquetting the char, and the storage and shipping of the briquettes. The general arrangement is shown in the flow sheet which appears as Fig. 6.

The dwellings for the employees consist of a boarding house for single men, and fourteen houses of three different types, i.e., Class A, Class B, and Class C. There are two Class A houses built in one block. These houses are for the use of the Manager, Chemical Engineer and any other resident executives. There are four Class B. houses built in two blocks of two each, and eight Class C houses built in two blocks of 4 each. The classification has reference to size only, and in all the houses the maximum of comfort with a minimum of expenditure has been aimed at. The layout of the houses is shewn in Fig. 20.

(b) TYPE OF CONSTRUCTION

Owing to the uncertainty of the fire hazard in an operation of this nature the policy adopted by the Board was to construct the plant proper as nearly fireproof as possible. The main buildings were constructed of brick and steel with galvanized iron for a roofing material. The steel for the columns as well as the metal bins was fabricated and erected by the Dominion Bridge Company and the brick used in the walls was supplied by the Estevan Coal and Brick Co. of Estevan, Sask. Plates 1 to 8 show the plant under construction at different dates and indicate the type of construction used.

The only wooden construction used was the roof for the power house, the binder unloading shed, the shed over the track hopper, the shed enclosing the tar tanks and the briquette storage bin. The fire hazard in the sheds and bin is not very great, hence this cheaper type of construction. The houses are of wood but they are sufficiently far removed from the plant for fire protection. In addition hydrants and hose are provided for immediate use in close proximity to these dwellings. The location of these hydrants and hose boxes has been approved by the Western Canada Fire Underwriters Association.

The wisdom of building fire proof buildings was amply demonstrated during the early stages of plant operation. A slight explosion within the retort resulted in a large amount of incandescent coal being discharged on to the floor of the retort house which immediately took fire and burned out two window sashes and the electrical connections. The damage was small but in another type of building this accident might have resulted more seriously.

(c) RAW LIGNITE HANDLING EQUIPMENT

This equipment includes the machinery for the unloading of the raw lignite as it is delivered from the mines, and for its crushing and storing preparatory to being processed.

The lignite is delivered in bottom dump steel cars, and is dumped into a large double compartment hopper through grids capable of passing 10″ lumps. The coal is discharged from the bottom of these hoppers by means of two lateral conveyors which discharge to an inclined apron feeder leading to the crusher. The crusher is a Jeffrey swing hammer pulverizer type B - No. H. 3 — driven by a 75 H. P. Lincoln electric motor at a speed of 1,000 r. p. m. It was intended to crush the coal below ⅜″ and in this respect the installation proved satisfactory (see Appendix 23).

The entire equipment for the handling and crushing of the raw lignite was supplied and installed by the Jeffrey Manufacturing Co. and was designed to handle a maximum of 50 tons per hour.

The crusher discharged into a vertical elevator placed between two large cylindrical bins where the crushed coal was stored. These bins are 39 feet high and 25 feet in diameter and have a capacity of 300 tons each so that a three days' supply can always be maintained in the event of delays in delivery. Owing to the danger of fire due to spontaneous combustion these bins were constructed of reinforced concrete and steam connections were made so that a jet would be available in case of serious outbreaks of fire. (The actual results obtained in this connection are described in Appendix 23).

The bins are provided with a conical bottom for discharge, and a belt conveyor is provided which collects the coal from the two bins and delivers it to an inclined bucket elevator which carries the coal to the dryer bins. Fig. 21 shows an elevation of these bins together with their discharging device.

(d) DRYING EQUIPMENT

In appendix 18 it has been clearly shown why the decision was made to dry and carbonize in two operations. The drying apparatus selected were two C. O. Bartlett and Snow rotary dryers. These machines are of somewhat different construction to the ordinary single shell rotary type, and are known as the four compartment coal dryers. They consist essentially of revolving steel cylinders 55 feet long and 6 feet in diameter, provided with the necessary fittings for the continuous introduction of wet lignite, for the discharge of dry lignite, and for the removal of the evaporated moisture. The first 20 feet of each drum is a straight cylindrical section, and the remainder is of four compartment construction having clear spaces between the compartments, through which the hot gases will circulate. They are enclosed in a brick work setting quite similar to the settings of horizontal return tubular boilers.

The wet lignite is introduced into the inside of the cylinder at one end and is divided into four independent streams when it reaches the four compartment section. It is constantly elevated by a series of lifting flights properly arranged inside the cylinder, and showered through the hot gases and against the hot cylinder plates. At the same time it is propelled toward the discharge end, where it is discharged after the desired amount of moisture has been drawn off.

The hot gases which supply the heat for drying are introduced into the brick setting at the feed end, and circulate first around the outside of the cylinder and then through the space between the compartments, thus coming in contact with the heating surface of the cylinder and giving up the greater portion of their available heat. After the gases have passed around the outside of the cylinder they may be directed by means of a series of dampers in any of three ways;

1. They may be passed directly into the fan or stack.
2. They may be passed through the inside of the cylinder in the same direction as the lignite and in direct contact with it, and then into the fan or stack.
3. They may be passed through the cylinder in an opposite direction to the lignite and in direct contact with it and then into the fan or stack.

Fig. 24 shows a diagram of this damper arrangement and a sectional elevation of the setting, and plates 9 and 10 show the brick work setting and shell during erection. As will be noted a furnace is provided for supplying heat to the dryer shell. This furnace was in addition to a connection from the carbonizers and was to be used only in the event the waste gases from the carbonizers proved insufficient for the drying operation.

Two dryers were installed which had a guaranteed capacity of 150 tons each. It was considered at the time of their purchase that a possibility existed of selling dried raw lignite as a separate product, and provision was made for diverting the output of one dryer if such a market developed but up to the present there has been no call for such a product.

Steel bins were provided, capable of holding 50 tons of raw crushed lignite, which served for feeding the dryers. A ratchet device operating a small screw conveyor regulated the amount of coal entering the shell thus ensuring a constant feed. Plate No. 10 shows this feeding device also the furnace referred to above. The dried lignite as discharged from the dryer was elevated by a vertical bucket elevator discharging to a screw conveyor which served for distributing the coal to any section of the dried lignite bin desired. The sequence of the inclined elevator and dryer feed bins is shown in Fig. 6.

(e) CARBONIZING EQUIPMENT

This equipment includes the retorts, the gas purification system, the handling machinery necessary for feeding the dried coal to the retorts, and such conveyors and elevators as were required for removing the carbonized residue and conveying it to the briquetting room. The bin for the storage of dried lignite is of steel construction, capable of holding 600 tons of dried lignite, with discharge spouts located above the retort hoppers. Flexible steel chutes are provided so that two carbonizers can be supplied from the one discharge.

Six carbonizers were installed, and as they have been fully described in Appendix 18 no further description will be included here. The location of the retorts is shown on the plan view of the retort house, Fig. 19, and a section of the carbonizer and bin for feeding is shown in Fig. 41. As will be noted the retorts are built back to back so that each bench consisted of three retorts, Nos. 1, 3 and 5 on east side and Nos. 2, 4 and 6 on west side of carbonizer building. The dried lignite is fed in from the top as above described and passes through the retort by gravity, its rate being controlled by the speed of the discharge paddle at the bottom. It is carried by screw conveyors to an elevator which discharges in the storage bin above the briquetting building.

The discharge mechanism of the retorts is probably worthy of mention here as this feature gave considerable trouble until it was redesigned. The original method of removing the carbonized residue was by means of a gate valve which was set to allow the proper amount of flow through the opening by gravity while the residue was cooled by means of water sprays. This system of withdrawal and cooling was an absolute failure, and a new discharge was designed which removed the coal positively by means of a paddle wheel, the speed of which was adjustable, the cooling being effected by means of a water jacket. This system was fairly satisfactory. Fig. 22 shows a sectional perspective view of the carbonizers as originally designed and installed.

The gas from the retorts is taken off under a slight pressure by means of offtake pipes, and after being purified is returned to the combustion chamber of the retorts. The apparatus for the recovery and purification of the gas was designed and installed by the American Chemical Machinery Company of Chester, Pa., the representatives on this continent of Blair, Campbell & McLean — Scotland. The details of the equipment and its location are shown in Figs. 17a and 19.

This apparatus regulates the flow of gas from the carbonizers; cleans the gas of dust, tar and water soluble matter, thus making it suitable to be returned to the carbonizers and burned as a fuel; separates the tar and solids from the scrubbing water; cools the water for reuse and collects the tar.

The apparatus consists of the following:

(*a*) 1 Dust Separator.
(*b*) 1 Centrifugal Scrubber.
(*c*) 1 Exhauster.
(*d*) 1 Gas Control Regulator.
(*e*) 1 Seal Pot.
(*f*) 1 Observation Box.
(*g*) 1 Separating Tank.
(*h*) 1 Interchangeable Type Cooler.
(*i*) 2 Storage Tanks.
(*j*) 3 Pumps.
(*k*) All necessary piping, fittings and valves to make the installation a complete unit.

The above letters appear as identification marks in Fig. 17a, — showing layout of gas handling equipment.

Operation

The gas, by virtue of the Exhauster (c) is pulled from the gas outlet of the carbonizers, at a pressure of from zero to one inch water gauge, through the raw gas line to the dust separator (a). From the dust separator, the gas passes directly into the bottom of the scrubber (b), where it is intimately brought into contact with the scrubbing water as described below, which removes all light tar and water soluble constituents. It then passes through the exhauster (c) as clean gas into the manifolds leading to the carbonizer burners. Water is drawn from one of the storage tanks through the interchangeable cooler (h) to the scrubber (b), flows through the scrubber, seal pot (e), observation box (f) and into the second storage tank, whence the tar and water are finally separated and the process repeated. The storage tanks are connected to the pumps in such a manner, that while one tank is being filled with the emulsion, the second tank is being emptied.

(a) *Dust Separator*

The function of the dust separator is to remove all dust and solid matter from the fresh gas as it comes from the carbonizers and to take out the heavy tars. The separator is constructed entirely of cast iron with internal baffle and water spray nozzles and set over a sump which forms a water seal and reservoir for the dirt. One side of the sump is inclined so as to facilitate the removal of the dirt and heavy tars.

(b) *Centrifugal Scrubber*

The centrifugal scrubber removes from the gas all light tars and water soluble matter. It is constructed entirely of cast iron with steel shaft supported by radial and thrust bearings. Cast iron buckets are securely fastened to the shaft, which is made to rotate at a speed of 250 r. p. m. by means of a 5 H. P. motor through a pulley fastened to the shaft. The gas enters the scrubber at the bottom and rises counter flow to the scrubbing water. The gas, in travelling upward, is made to pass from side to side through each scrubbing chamber and as the shaft revolves the deflectors act as a scrubbing medium and impart to the gas a centri-

fugal motion. The washing water is fed at the top of the scrubber and is carried by means of division plates into the above mentioned buckets, where it is immediately driven by centrifugal force through the deflectors in the form of a fine spray. It then travels from plate to plate and bucket to bucket until it reaches the bottom, whence it is discharged from the scrubber, carrying the tar and impurities with it.

(c) *Exhauster*

The suction side of the exhauster is connected to the gas outlet of the scrubber, thus pulling the gas through the entire system and discharges the gas into a manifold which leads back to the burners in the carbonizers. The exhauster is of Canadian-Buffalo Forge type and is complete with outboard bearings, and motor mounted, as a complete unit, on the same cast iron base.

(d) *Gas Control Regulator*

The function of this instrument is to regulate the pressure of from zero to one inch water gauge, at the gas off-take of the carbonizer and to deliver the gas back to the carbonizer burners at a pressure of about six inches water gauge. The regulator is of the type manufactured by Isbell-Porter Co. with outside adjustment to give the exact regulation desired.

(e) *Seal Pot*

The seal pot prevents any leakage of the gas from the scrubber or of air into the scrubber at the water discharge connection. It is constructed entirely of cast iron with internal baffle and brass air cock on cover to prevent the formation of an air pocket.

(f) *Observation Box*

The observation box is connected to the discharge of the seal pot in order to make it possible for the operator to observe the exact physical nature of the scrubbing water as it leaves the scrubber. The box is constructed of cast iron with pyrex glass sides held in place by polished brass frames with a brass water cock on the top to prevent the formation of an air pocket.

(g) *Separating Tank*

The separating tank is constructed of steel plate with loose cover. The object of this separator is to separate the tar from the water, keeping the emulsion warm enough so that the tar will float, and draw off the water from the bottom and the tar from the top. Overflows are provided to facilitate its operation.

(h) *Interchangeable Cooler*

The interchangeable cooler takes the once-used water after the tar has been separated and cools this water to be circulated back through the scrubber. It consists of two cast iron headers connected by long steel tubes expanded into tube plates which are fastened to the headers and each end is covered by a cast iron cover plate. The baffles in the headers cause the water to flow back and forth in a zig-zag path through the tubes while water is made to flow over the tubes. On the top of each header are pipe plugs which can be removed when starting up to prevent the formation of air pockets.

(i) *Storage Tanks*

Two large, mild steel storage tanks with steam coils and traps are used for collecting the tar and water. Both tanks and one coil were furnished by the Lignite Board, but the coil for the second tank was designed, furnished and installed by the American Chemical and Sugar Machinery Company.

(j) *Pumps*

Three horizontal, direct acting, simplex steam-driven pumps are used in conjunction with this apparatus. These pumps are all of iron construction and are designed with large valves and of ample size to handle the emulsion of tar and water used. The first pump is used to draw the water from the separating tank and pump it into the storage tanks. The second pump is used to withdraw the water from the storage tanks, pass it through the interchangeable cooler and then into the scrubber. The third pump is used to remove the tar from the storage tank.

(k) *Piping and Fittings*

The raw gas piping which connects the gas offtake of the carbonizers to the inlet of the dust catcher is wrought iron pipe with cast iron fittings. These lines are designed to have a slope of approximately one inch per foot and auxiliary water wash-out lines are connected to each gas offtake to facilitate the removal of any tar or solid matter which might accumulate in the piping. Each offtake line contains a butterfly valve to regulate the flow from the carbonizer also a gate valve, which serves as a by-pass so as to allow any undesirable gas to escape to atmosphere. These lines are fitted with expansion joints between fixed points in the line. The return piping from the exhauster to the carbonizer burners is wrought iron with cast iron fittings with valves inserted to regulate the flow of gas to each burner manifold.

The piping leading to and from the gas regulator is designed in such a manner as to connect the inlet and exhaust side of the blower. The pressure connection on the regulator controls the system by allowing more or less gas to pass from the outlet to the inlet side of the exhauster by virtue of the pressure in the raw gas line.

All the tar and water piping is wrought iron with cast iron fittings and this piping is so arranged that either of the storage tanks can be by-passed.

(f) MIXING AND BRIQUETTING EQUIPMENT

On reference to the flow sheet which appears as Fig. 6, it will be noted that the char after leaving the carbonizers is stored in the residue bin and from there flows through the various machines to the briquette press. An apron feeder delivers the char from the bin to a horizontal paddle mixer where it is mixed with the binder. The discharge is to a vertical fluxer from which the mixed material passes to the edge runner thence to a second steam jacketted paddle mixer, used as a temperer, and is then elevated to the press. The

briquettes are discharged on a shaking screen to remove fines and descend by means of a chute to a cooling table located in an underground tunnel through which air is circulated by means of a fan. The cooled briquettes are elevated by a continuous bucket elevator to the briquette storage bin and are discharged in the bin by means of a distributing conveyor. The fines are returned to the last mixer by means of a belt conveyor. After a few days storage the briquettes are sufficiently hard to stand shipment and are loaded from the bin into either box cars or gondolas as desired. The briquetting room and layout of the machinery are shown in plan and elevation in Figs. 18 and 19.

The binder is delivered on the receiving spur in tank cars. It is placed in the binder unloading shed which is heated by means of steam coils. Steam is also circulated in the pitch car through coils provided for that purpose. When fluid the pitch flows by gravity to a large underground concrete reservoir capable of holding 41,900 U. S. gallons, equipped with steam coils for keeping the pitch hot. A Kinney Rotary plunger pump delivers the pitch from the reservoir to a small supply tank equipped with an overflow pipe which returns the excess pitch to the reservoir and insures a constant head. (This tank is shown in Fig. 63, P. 77). The flow of pitch from this tank to the mixer is by gravity and the quantity is regulated by means of a steam jacketted valve.

Description of Apparatus

The mixers used are of three different types which were included, in order that their respective merits might be thoroughly tested and the best suited ultimately selected.

The horizontal mixers were steam jacketted machines manufactured by the Mashek Engineering Company being their type M (Catalogue No. 4) and are driven by gear and pinion. On the center shaft of the mixer there are mounted separate cast steel hubs. To the larger part of these hubs are bolted manganese steel mixer blades, plain straight blades curved to overcome wear, which are followed by spring loaded spreader blades, the wearing end of which is manganese steel. On the opposite side of these blades are placed large scraper blades made of manganese steel bolted to the hubs so as to plow off the squeezed, pugged material after the spreader blade passes from it. On the end is a special lock hub, on which are mounted two manganese steel expelling blades. Provision is made in the mixer for the introduction of water or steam as might be required.

The vertical fluxer was supplied by the General Briquetting Company who secured it second hand. It was originally manufactured by the Traylor Engineering Company and had been in service only a short while. The machine is 3-½′ in diameter and 8′ high with a central revolving shaft which contains 8 cast iron blade sockets set at 90° with each other alternately from the bottom to top. Each blade socket is fitted with two shaft blades making a total of 16. Immediately under each set of shaft blades there are stationary shell blades fitted to the shell in such a manner that they can be easily removed from the outside. Provision is made for blowing steam into the mix during its passage through the machine.

The edge runner or masticator was supplied by the General Briquetting Co. The machine is a Chilean mill, and consists of a heavy cast iron base with pan, frame, overhead driving gear, and two rollers. The top of the cast iron base forms the floor of the pan proper and has a machined surface covered with hard cast iron lining plates resting on the floor of the pan. The frame consists of two inverted "A" shaped side standards set on separate concrete foundations in an inclined position to insure greater rigidity. A pair of 25 pound channels connects these standards and serves as a support for the driving gears. There are two mixing rollers 48″ diameter and 30″ face, revolved by means of forged steel crank shafts 6″ in diameter which are fastened into a cast iron hub made in halves, bolted to a vertical shaft, which arrangement permits the necessary variation in movement of the rollers.

The mixed material is fed in on the outer rim of the pan and is worked towards a central discharge by means of adjustable blades and scrapers giving a combined crushing and mixing action.

The briquetting press is a Belgian Roll press making a two ounce egg shaped briquette. The rolls are 26-½″ in diameter by 11-½″ face. Each roll has six rows of eggette shaped moulds, 36 moulds to the circle, or a total of 216 moulds to each roll. The press is provided with a feeder and regulator arrangement directly above the rolls by which the flow of the material into the rolls can be controlled.

The cooling table is a metal conveyor travelling at a very slow rate, located in an underground tunnel which has an opening through a stack to the atmosphere. One No. 7 conoidal exhauster is connected to the opposite end of this tunnel which is used for circulating a current of air over the hot briquettes in order to hasten cooling. The fan is capable of exhausting 20,000 cu. ft. of air per minute. The metal conveyor and the continuous bucket elevator, which elevates the cooled briquettes to the briquette storage bin were supplied and installed by the Jeffrey Manufacturing Company.

(g) STORAGE AND LOADING

The cooled briquettes after being discharged from the cooling table are elevated to the top of the storage bin where they are distributed to any portion of the bin desired, by means of a distributing belt conveyor.

The bin is a wooden structure 80 feet long by 16 feet wide by 55 feet high and is capable of storing 600 tons of briquettes. The floor of the bin slopes from back to front at an angle of 60° and chutes are provided at intervals along the length for discharging the briquettes. A track is provided in front of the bin so that the briquettes fall by gravity through the chutes direct into the cars.

(h) POWER HOUSE

The power plant consists of three 150 H.P. H.R.T. boilers, a 400 K.V.A. unit, a 100 K.V.A. unit, a 30 K.V.A. unit and a 25 H.P. engine connected to a D.C. generator for excitation. A section and plan view of the power house is shown in Figs. 26 and 25.

The boilers were manufactured by the Vulcan Iron Works, Winnipeg, and guaranteed to meet the requirements of the Province of Saskatchewan. They are 72″ in diameter and 18 feet long constructed of 17/32″ plate, containing 72 lap welded tubes 4 inches in diameter set in horizontal and vertical rows. They are suspended from steel beams by means of 1-½″ "U" bolts connected to hangers on the boiler, the beams being supported by steel I beams of sufficient strength to carry the weight.

Each boiler is provided with twin 3″ pop safety valves, one 8-½ inch steam gauge, three ¾ inch gauge cocks, one ¾ inch water gauge glass, one 18″ water column and one 2″ blow off valve of the "Duro" type. The grates are the diagonal type 6″ x 36″ having ½ inch openings, forced draft being provided by a Coppus blower. Two duplex piston pumps for boiler feed water are provided in conformity with provincial regulations also one Cochrane open type vertical feed water heater with oil separator, filter and float.

The 400 K.V.A. unit consists of a 400 K.W. 3 phase, 60 cycle, 600 volt Canadian General Electric Co., generator, direct connected to a Robb-Armstrong cross compound Corliss engine. This unit was built in April 1908 for the Lehigh Portland Cement Company, and was in operation at their plant at Belleville, Ont., for a portion only of the time until 1918 when it was purchased by the United States Government (Ordnance Dept.) from whom the Board purchased the machine after inspection had revealed it to be in good condition. When new it had a guaranteed water rate of 19 pounds per H.P. hour at full load, operating non-condensing.

The 100 K.V.A. unit was purchased from the MacGovern Company. It consists of a 100 K.W., 600 volt, 60 cycle, 3 phase, generator direct connected to a Westinghouse single acting compound engine. The machines had been in service a number of years but thorough inspection revealed them to be in fairly good condition.

Excitation for the two generators is provided by one exciter unit comprising a 25 K.W. 125 volt Westinghouse generator direct connected to a Westinghouse vertical duplex engine. This engine is also belted to a small 30 Kilowatt 550 volt 3 phase 60 cycle generator with self-exciting revolving armature, which is used for light loads during experimental operation.

Two power lines were provided so that either of the two large generators could be used separately, and provision was made for synchronizing the two units in the event the power requirements made it necessary. A three panel switchboard, purchased from the Monarch Electric Co., was installed containing all the necessary instruments for power and lighting control.

(i) WATER SUPPLY

The water supply is obtained from the Souris River, a distance of 1-¼ miles from the plant, through an existing pipe line built to supply the requirements of the two neighbouring mining companies. An extension of this line was built and connection made with a large semi submerged, covered concrete reservoir capable of holding 150,000 Imperial gallons.

In order to provide working pressure an elevated tank was erected which has an additional capacity of 83,000 Imp. gallons. This tank is supplied by means of a Lea-Courtenay horizontal type double suction single stage volute pump having a 3″ suction inlet and a 3″ discharge outlet. The pump delivers 250 U.S. gallons per minute when running at 1,750 r.p.m. and is direct connected to a 20 H.P. Lincoln Electric motor. In addition an 18″ x 10″ x 12″ standard make, underwriters' type fire pump is installed capable of delivering 1,000 U.S. gallons per minute. This latter pump is only for use in the event of fire and has been passed by the Western Canada Fire Underwriters Association. The two pumps described are located in the power house and are shown in Figs. 25 and 26 while Fig. 20 gives the location of reservoir, overhead tank, supply and service lines.

(j) SEWAGE DISPOSAL

Plant and house waste is taken care of by means of a double compartment sedimentation tank. The water after partial purification is passed from the second compartment by means of a syphon to sand beds. The sludge is periodically dumped direct on the prairie. The location of the sewage disposal plant is shown in Fig. 20.

(k) OFFICE BUILDING

The floor plan and cross section of the office and laboratory building is shown in Fig. 23. The building contains the general offices and an office for the manager, together with laboratories and office for the chemical staff. The laboratories are equipped for coal and gas testing and such other work as enters into the control of the process.

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APPENDIX 23

Operations during 1921 and 1922.

By R. A. STRONG

The operations during the years 1921 and 1922 included every department of the plant and the results obtained are discussed under the following heads:-

(*a*) Raw Material.
(*b*) Crushing.
(*c*) Storage.
(*d*) Drying.
(*e*) Carbonizing.
(*f*) Briquetting.
(*g*) Power House.
(*h*) Water System.
(*j*) Sewage System.

It is not the purpose of this report to describe in detail the apparatus used in each department as this has been fully covered in appendix 22. It is merely a record of the operating results and if these seem negative in character it should be remembered that the Board were pioneers in large scale work of this nature and success in every department of an entirely new process could not reasonably be expected.

(*a*) RAW MATERIALS

It was the original intention of the Lignite Utilization Board to avail themselves of the cheap lignite in the district which is in the form of slack. There are two distinct disadvantages in connection with the use of such material:-

(1) Lack of adequate supply.

(2) High ash content of the slack which renders it unsuitable for briquetting.

It is estimated that there are only about 30,000 tons of slack available per annum in what is known as the Souris field. This is only 50% of the total requirements of the Board's plant, and the remainder would have to be made up of mine run coal. A larger demand exists for slack coal now than when the Board was formed, and it is no longer a problem to dispose of what was formerly a waste product. It is being burned with success on chain grate stokers, and by reason of its cheapness is in considerable demand. Several different types of stoves have also appeared in the district which can be operated successfully on this material.

The slack is obtained by screening the mine run coal, and by cleaning up the mines at intervals. With this latter method a large percentage of clay is mixed with the coal, which increases its ash content to such an extent that it is entirely unsuitable for carbonizing and briquetting. In view of the fact that not more than a 50% yield is obtained in the form of briquettes it is evident that the ash is practically doubled, and consequently it is essential that the ash in the original material should be kept as low as possible. In addition the ash has a low fusion point, and when high ash briquettes are burned, clinkering becomes a nuisance and will cause the consumer to condemn the product.

During operations at Bienfait observations were made in regard to this problem and coal was purchased from all the adjoining mines and samples taken. Below is appended a table showing the ash content and shipper's name of material received. Each analysis represents a car load, the sample being taken while the coal was being crushed for processing. In order to note the wide difference between the ash content of slack and the ash content of mine samples, the 4th column shows ash content of such samples taken by Alex. McLean, (See Section III P. 37, also pp. 179 and 180).

ASH TABLE

Mine	Kind of Coal	% Ash	% Ash in mine sample as determined by McLean
Bienfait	Slack	12.0	5.2
"	"	14.4	5.7
"	"	8.7	...
Crescent	"	16.1	5.5
"	"	15.5	...
M. & S.	"	13.6	6.9
"	"	13.2	7.2
"	"	13.8	12.1
"	"	12.8	...
W. D. C.	"	11.5	6.8
Bien. Comm.	"	9.7	5.3
Average		12.9	6.8

When it is realized that a briquette made from the slack above mentioned will contain approximately 25% ash, it can readily be seen that a briquetting proposition using slack from this district could never hope to produce a commercial product which would compete against the better grades of coal. Mine run coal on the other hand from several of the above mines runs between 6 and 7% ash and briquettes from this material will only carry 12 to 14%.

(b) CRUSHING

The coal was delivered to the Board's plant in bottom dump steel cars, and unloaded over a track hopper. Two lateral conveyors feeding an inclined apron conveyor delivered the coal to a swing hammer pulverizer where it was reduced to a proper screen size for drying and retorting. The crushing equipment consisted of a Jeffrey type B. No. H.3, swing hammer pulverizer driven by a 75 H.P. Lincoln electric motor at a speed of 1,000 R.P.M. This crusher together with the conveyors was designed to handle 50 tons of lignite per hour but as installed it did not exceed 30 tons per hour. In an attempt to rectify this, the manufacturers made certain changes in the installation but no thorough tests has been undertaken since this change.

The slack coal as received does not carry the water content which is found in mine run coal. This is probably due to the fact that a large percentage of it is allowed to remain in the mine for a considerable period before being cleaned up.

Below is appended a table showing the moisture content of slack coal as received.

MOISTURE TABLE

Mine	Kind of Coal	% Moisture
Bienfait	Slack	30.0
"	"	28.8
"	"	30.4
Crescent	"	25.6
"	"	27.5
M. & S.	"	30.3
"	"	26.0
"	"	28.2
W. D. C.	"	30.9
Bien. Comm.	"	31.8
Average		29.0

(The mine run coal will average between 33 and 35% from the above mines). Even this with lowered moisture content considerable difficulty was encountered in reducing the coal below ¼". The crusher would occasionally get plugged up and would have to be stopped and cleaned out. With a higher water content this trouble would, of course, be increased.

The crusher delivered a fairly uniform product and in this respect was satisfactory. The curve in Fig. 8g, shows a screen analysis of the product.

(c) STORAGE.

The crushed coal was stored in two large concrete storage bins with conical bottoms from which the coal was discharged. The coal as delivered from the crusher is in a finely divided state and in this condition offers no great difficulties in storage. A rise in temperature in the coal mass was noted but no fire troubles developed. During subsequent operation when a larger sized coal was used considerable difficulty was experienced from spontaneous combustion, due to the shape and size of the storage bin. The discharge spout in the bottom and the manhole in the top caused a current of air to circulate through the coal mass which resulted in a rapid rise in temperature and ignition. The original plans had provided for steam jets in the bin but these had never been installed.

In commercial operation, the coal will only remain in storage for a very short time and consequently this trouble would be largely alleviated.

(d) DRYING.

Two C. O. Bartlett & Snow rotary dryers were installed for drying the coal prior to its being delivered to the retorts. These machines were the single shell multiple division type, 55 feet long, six feet in diameter, driven by a variable speed motor at a speed of from 6 to 8 R.P.M. A special brick setting was provided and flues arranged so that experiments could be made on the efficiency of various methods of circulating the hot gases. The dryer was heated by means of a furnace and was also connected by a tunnel to the carbonizers. The hot flue gases from the retorts were intended to supply a large portion of the heat necessary for this operation. An induced draft fan was used for circulating the gases and suitable dampers were provided for controlling their path. Figure 24 shows a diagrammatic elevation of this installation. The capacity was guaranteed at 150 tons of dried coal per 24 hours.

The first attempt at operation resulted in bad fires and although no damage was done it showed that in order to dry lignite in this type of dryer very careful regulation of temperatures was essential. The fires on both occasions started at the discharge end and were swept towards the inlet by the gases which were travelling in a contrary direction to the flow of the coal and were only extinguished with considerable difficulty. The operators were not very familiar with an installation of this type, and this may, in part, have been responsible for the trouble. In subsequent operations the dampers were so arranged that the hot gases were sent through the shell in the same direction as the flow of the coal. Temperature of the discharge was taken continually and samples collected for analysis. By this method of operation very uniform results were obtained and all danger from fire was eliminated. In practice a recording thermometer with a maximum and minimum alarm would be advisable.

The results in the following table are from a week's operation and are typical of the results obtained during the entire period of operation.

Dryer Results

Maximum temperature of discharge	203	degrees F.
Minimum " " "	154	" F.
Average " " "	175	" F.
" moisture in feed	29%	
" " " discharge	5.7%	

The screen analysis of the product is shown in Fig. 8 f.

The dryers were never operated at capacity and the indications were that they would not attain it. No determined effort, however, was made to definitely prove this in view of the subsequent difficulties encountered with the carbonizers. The operation was intermittent and it was impossible to say what results would have been obtained had the machines been operated for a long period of time which would have allowed the entire setting to become thoroughly heated.

The fuel consumption was very high being 380 lbs. per ton of coal dried or 19%. The effect of the flue gases from the retorts was negligible as this heat was entirely dissipated in the long underground flue leading to the dryer setting. It must be remembered, however, that during this period of operation of the dryers only one of the retorts was being operated. Had the waste heat from six retorts been available very much better results would undoubtedly have been obtained. On reference to Fig. No. 24, it will be noted that the fans had been designed to remove these gases from the carbonizers, circulate them around the dryers, and thence discharge them to the atmosphere. Operation determined that they were not sufficiently powerful for this total load, but at the same time were so strong as to pull (due to their proximity to dryers) a large quantity of the fine dust out of the dryers which was lost, as no dust collector had been installed. This fan trouble could have been corrected by installing a fan closer to the retorts which would have allowed of increasing the suction for removing the flue gas, and a second fan in close proximity to the dryers could have been used for circulating the hot gases. In this way the dust losses would have been materially decreased.

Storage of the dried lignite proved to be a very difficult matter. The material was very liable to fires by spontaneous combustion and at no time during the entire period of operations was the plant entirely free from fires in the dried coal storage bin.

(e) CARBONIZING.

The main causes of the previous failure were due to leaky construction and failure of floor material. The floor has been built of carbofrax tiles one inch in thickness and these had cracked badly, allowing the escape of products of combustion into the carbonizing chamber. In some cases the tiles were so badly cracked as to allow of coal falling through into the combustion flue. The carbonizing chamber leaked to such an extent that air entered the retort or gas escaped to the atmosphere as the pressure within varied below or above atmospheric pressure.

As a result of these troubles it was decided to call in Mr. Chas. V. McIntire of New York, and consult with him as to the best method of eliminating the weaknesses which had been discovered. This was accordingly done and Mr. McIntire rendered his report on the reconstruction of these units.*

Mr. McIntire's recommendations called for the reconstruction of the retorts using six combustion flues instead of three as formerly. The floor material was to be made of special shapes in high grade clay fire

* This report appears as appendix 24.

brick 12″ x 12″ x 2″. The inclined partition dividing the combustion flues and the air preheating flues were to be at least twice as thick as formerly and were to include a course of insulating brick, as shown in sketch No. 3 appendix 24. Expansion joints were to be provided on both sides of the retort. The arrangement of the floor tiles and the expansion joints are shown in sketches 4 and 5 appendix 24. The side walls were to be built of 9″ firebrick set in a refractory bonding cement.

In order to eliminate the leaks referred to Mr. McIntire recommended that a system of regulation be installed in order that balanced pressures might be obtained within the carbonization chamber and combustion flues. Butterfly valves were to be inserted in the mains which were to be operated by regulators and a small gas holder was to be placed in the system to take up pressure fluctuations and insure a constant pressure at the burners. Sketch Nos. 1 and 2 of appendix 24 show diagrammatically the installation as proposed and the pressures desirable for successful operation. In order to regulate the pressure in the combustion flues slide bricks were to be placed at the upper ends of all these flues. Mr. McIntire did not recommend the use of calorized metal or carborundum for a floor material both of which had been considered. He concluded his written report by the statement that in his estimation the capacity would be relatively low considering the size of the apparatus and the cost of construction.

In view of this report it was decided to reconstruct one carbonizer along the exact lines suggested, and at the same time reconstruct two others similarly with the exception of the floor material. The Carborundum Company insisted that their product had been improved in the time intervening since the former tiles were purchased, and suggested that a special hollow tile be tried. This was accepted as one alternative, and for the other it was decided to use the old carbofrax tiles doubled with the joints staggered, and the both sections bonded together with a refractory cement, manufactured and recommended by the Carborundum Co. (This construction is shown in Diagrams 1 and 2, on next page.*)

The decision to rebuild three retorts using different materials was based on the necessity to either prove or disprove the retort in the shortest time possible, with the smallest outlay of capital expenditure, and it was felt that this could best be accomplished by doing all the construction work at one time. The question had been thoroughly discussed in conference at which Mr. McIntire was present, and he had given his verbal approval to this course of action.

Construction on the new retorts was started in May and finished early in September. In order to conform to the recommendations above outlined it was necessary to revise the gas system as originally installed, to include a 5,000 cu. ft. gas holder which was erected outside, close to the retort house. Butterfly valves were placed in the gas mains and these connected to regulators supplied by the Ratteau Battu Smoot Engineering Corporation. The makers claimed a sensitiveness of 1 mm. for these machines and subsequent operation proved this to be correct. The revised layout is shown in Fig. 17 b.

The cement used for bonding the side walls was supplied by the Harbison Walker Refractories Co. and was sold under the name of "Fire Bond". It proved to be satisfactory in every respect and produced a very tight wall.

OPERATING RESULTS, 1922.

The first retort to be operated was the one with the carbofrax hollow shapes. A new discharge had been designed which consisted of metal spouts surrounded by a water jacket and terminating in a paddle wheel. The speed of the wheel was adjustable so that a uniform discharge from every channel was obtainable. This arrangement worked fairly satisfactorily. The metal baffles had been decreased in size allowing more space for the gas. The former narrow space between the cover plate and the top of the baffles had been subject to criticism, the objections being its susceptibility to plugging with dust and tar. This prophecy was fulfilled and although no shut downs were directly due to this cause, after every shut down a large accumulation of dust and tar was found at this point. The increase in this space did not eliminate the trouble entirely although it had a beneficial action.

The clearance between the baffles and the floor had been decreased which resulted in the elimination of the former troubles due to fine coal but made the retort entirely too liable to plugging from foreign matter or large pieces of coal which would accidently fall into the charging hopper. The result of a piece of coal entering the retort which was too large to pass under the baffles was a consequent slowing up of the flow, and ultimately caking would occur due to deposition of tarry matter on the stagnant coal. Owing to the restricted space it was almost impossible to correct this difficulty by poking, and as a consequence a shut down nearly always resulted from an occurrence of this nature. When this trouble occurred high temperatures would result in the combustion flue and the smooth working of the retort would be entirely upset.

It was necessary to have the regulators adjusted by the manufacturers before they functioned properly but after this was done they left little to be desired as far as regulation was concerned. Pressures were maintained as follows:-

Bottom	— .05	inches of water
Middle	.00	" " "
Top	+.03	" " "

The gas exhauster, which was a No. 10 type B. volume exhauster, supplied by the Buffalo Forge Company, gave continual trouble, and when the temperatures were raised to the desired point the fan would not handle the gas which rendered the regulators inoperative, and the good effects of balanced pressures were lost. Pyrometers had been placed in the carbonizing chamber so that the temperature of the coal could be determined. It was found that the temperature in the coal had to be maintained between 1000 and 1100 degrees fahrenheit in order to obtain the degree of carbonization desired, i.e. between 8 and 12% volatile matter. Whenever it was attempted to raise this temperature above 950 degrees F. trouble was encountered at once, and the fan would not handle the gas. In view of this repeated result no further attempts at correct operating temperatures were made and the subsequent tests were carried out at this lower temperature. Representations were made to the manufacturers of the fan, but no satisfactory settlement was reached; and as it was apparent that with a proper installation, the retort would function mechanically without undue difficulty the remainder of the test was to determine whether the new carbofrax floor tiles would stand up. After a few days of operation sparks were seen in the combustion flues which indicated that the tiles were cracking and a subsequent shut down proved this to be the case.

This retort had been built originally with carbofrax as a floor material in order to get a high capacity. It was estimated that the capacity per 24 hours would be 16 tons of carbonized residue with a 10% volatile content. This capacity, however, was never attained, and with the new floor tiles which were much thicker the maximum capacity was between seven and eight tons per day. The temperature recorded

*For assembly drawing of re-constructed carbonizer, see Fig. 43.

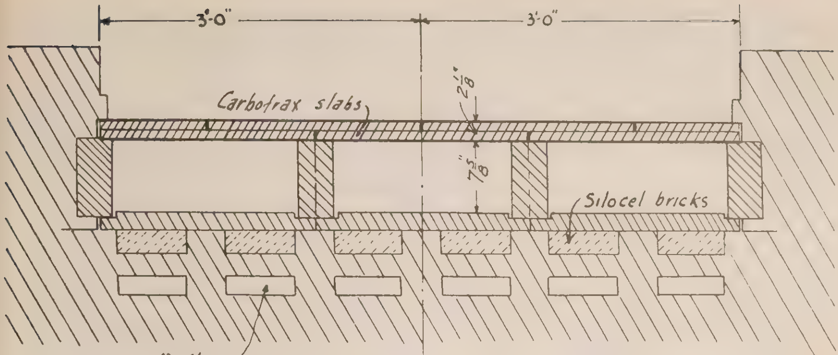


Diagram - 1

Double Tile Floor Construction

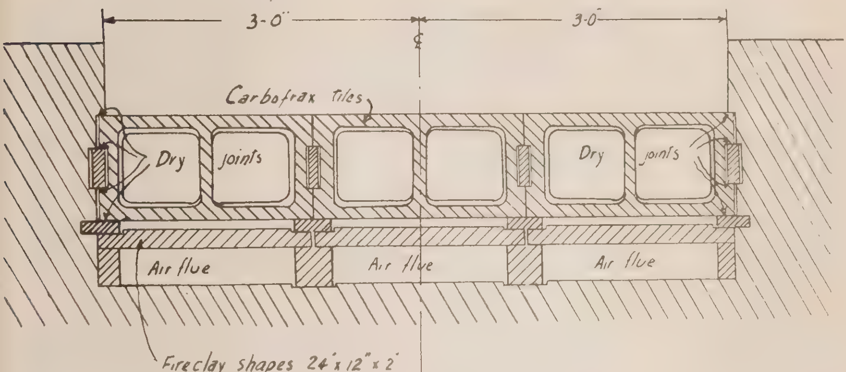


Diagram - 2

Carbofrax Hollow Tile Floor Construction

in the combustion chamber was 2200°F. and the flue gases left the retort at 1000°F. Although this flue gas temperature is entirely too high the heat was not lost but was conducted, as previously described, through a tunnel to the dryer setting where it was intended to be utilized in the drying operation.

The gas recovered was never sufficient to carry on the process, being slightly more than 50% of the total requirements. The difference was made up by burning fuel oil but in case the retort had proved successful a producer would have been necessary.

Average Analysis of Coal Fed to the Retort

Moisture	5.4%
Vol. Matter	34.1%
Ash	17.3%
Fixed Carbon	43.2%
	100.0%

Average Analysis of Char Recovered

Moisture	Nil.
Vol. Matter	16.2%
Ash	24.0%
Fixed Carbon	59.8%
	100.0

Yield — 72.2% of coal as charged (calculated from ash). The gas recovered amounted to 2.73 cu. ft. per pound of char. This is equivalent to 3942 cu. ft. per ton of coal as charged or 2910 cu. ft. per ton of raw lignite (30% moisture). These results compare very favourable with those obtained experimentally.*

*See table vii "Carbonization of Lignites," Part II, by Stansfield and Gilmore, Trans. Royal Soc. Canada, 1918.

The next test was made on the retort with the fire clay tiles as a floor material. This test was brief as it was soon discovered that the capacity of the retort was so low that it could never be considered as a commercial unit. The flue gases escaped from the combustion flues at temperatures ranging from 1200 to 1300 degrees F. It was difficult to run the discharge slow enough to effect the degree of carbonization desired, and it was soon apparent that Mr. McIntire's prophecy was only too true.

There still remained the retort which had been built of the old floor tiles doubled in thickness. A ten day test was carried out on this, and a host of mechanical difficulties were encountered which would have been largely avoided had proper means been provided for the removal of the gases and had regulation of pressures been possible. The greater part of the test was made with the gas exhausting to the atmosphere A higher temperature was maintained than in the former runs and a much better char was obtained.

Average Analysis of Coal Charged.

Moisture	4.1%
Vol. Matter	34.5%
Ash	17.6%
Fixed Carbon	43.8%
	100.0%

Average Analysis of Char Recovered.

Moisture	Nil
Vol. Matter	11.6%
Ash	24.8%
Fixed Carbon	63.6%
	100.0%

Yield — 71.0% of coal as charged (calculated from ash).

Towards the latter part of the test sparks were noticed in the combustion flues and it was assumed that the floor material had cracked, which was found to be the case, when the retort was cooled down.

During the trial operations of the retorts, detailed reports were prepared outlining the troubles encountered. Some of these, in log form, appear as appendix 26, and their value as records lies chiefly in the fact that they report day by day impressions, uncoloured by the perspective which time sometimes gives.

The conclusions reached after the completion of these tests were that the retorts as designed by the Board were a failure, and would have to be abandoned. The process had not proved economic and the carbonizers had failed to come up to expectations.

The process of drying and carbonizing in two stages is not economical. It involves a large capital outlay for dryers in addition to the carbonizing units and requires more labour for operating. The power requirements of the drying apparatus are appreciable, and from the results obtained as shown above, the fuel requirements for drying are high.

The carbonizers proved to be very low in capacity considering the size of the apparatus and the cost of construction. The chief disadvantages of this form of retort are:-

1. Angle of Inclination.

The retort was inclined at an angle of 45 degrees which had been found in Ottawa to be sufficient to cause the coal to slide readily. The coal used at Bienfait, however, contained a much higher percentage of dust which materially altered the natural angle of repose of the coal mass. The unexpected presence of these fines resulted in a layer of dust forming on the retort floor which acted as an insulator and probably partially explains the failure of the evolved gas being sufficient to carry out the carbonizing operations.

2. Metal Baffles to Regulate the Thickness of Material.

The clearance beneath the baffles did not allow of poking and the retort was subject to plugging from foreign matter and large pieces of coal. The cast iron baffles are subject to warpage and it is questionable what their life would be under constant operating conditions.

3. Inflexibility.

The operation of the retort depended on the accurate adjustment of feeding and discharge, of temperature and of pressure, and if any of these factors varied slightly the entire operation was upset.

4. Labour.

The average workman was not able to understand the intricacies of the system and it would have been necessary to have trained men. This adds considerably to the labour cost.

5. Floor Material.

The fireclay tiles were not feasible on account of the resulting low capacity. Carbofrax floor material resulted in a much greater capacity but even under these conditions only 50% of the estimated capacity was attained. The failure of the floor material together with the disadvantages above enumerated caused the abandonment of this type of apparatus.

(*f*) BRIQUETTING.

During the operation of the plant a number of briquetting runs were made in order to test out the adopted installation, discover its weaknesses, and make such changes as seemed necessary to produce a commercial briquette.

The conclusions drawn from these tests were that the layout was not suitable for briquetting lignite char, and that some of the machinery selected should not be included in a plant of this nature. In view of these conclusions a discussion of the mechanical difficulties encountered during the trial runs of 1921 and 1922 is desirable in order that they may be avoided in any future installations.

The previous briquettng experience of the Board had been confined to small scale experimental work where tests on all known binders were possible, and accurate control of all variables could be obtained. When it was desired to install a commercial plant at Bienfait, the services of the General Briquetting Company, New York, were retained to assist the Board's engineers in designing a layout. The layout decided upon appears in Figs. 18 and 19 and is described in Section VIII of the Secretary's report.

During Sept., Oct., and Nov., 1921, the operation of the plant was confined mainly to the drying and carbonizing equipment, but during December of that year two briquetting runs were made. The first test revealed difficulties with the binder system, and as this gave considerable trouble later a full discussion of the difficulties encountered will be discussed under *Binder System.*

The second attempt at operation was more successful although a great deal of trouble was encountered with the machinery and belting. A few tons of briquettes were made, however, though these could not be considered of commercial quality. The attitude at the end of the year was that while several weaknesses in the installation were very apparent, it was felt that these could be corrected, and briquettes produced.

The financial situation existing at the beginning of 1922 has been described in the main body of the report and its effect on the operation of the plant is fully shown. As a result of the delay occasioned by securing additional funds, no further operation of the briquetting machinery was possible until April 1922, but from then until the close of the year a large number of runs were made, and every effort was put forward to eliminate the weaknesses in the installation in order to produce a commercial product. It was, however, impossible to achieve this, and a verbal report was made in January 1923 to the supporting Governments that an entire revision was necessary. Plans were drawn up and estimates made for this revision, but unfortunately the recommendations of the Board were not acted upon.

The faults encountered will be covered in a discussion of the various machines under the following heads.
(i) Feeding Arrangements.
(ii) Mashek Mixers.
(iii) Vertical Fluxer.
(iv) Edge Runner.
(v) Belgian Roll Press.
(vi) Briquette Handling System.
(vii) Binder System.
(viii) Belting Trouble.
(ix) Dust and Moisture Troubles.
(x) Revisions Necessary.

A description of the briquetting installation appears on P. 185 et seq. and the flow sheet is shown in Fig. 6. As will be noted the char as discharged from the retorts is elevated to a bin situated at the top of the briquette room and the flow is by gravity to the various mixers.

(i) *Feeding Arrangements.*

The feeding mechanism for the char from the bin to the mixer was an inclined apron feeder operated by a variable speed motor for speed regulation. A gate valve on the spout of the bin, controlled by hand, regulated the amount of material flowing from the bin to the conveyor, and a scraper blade above the conveyor controlled the depth of char, thus giving a regulation of the amount entering the mixer.

The main criticism of this feeding arrangement is its entire failure to give the regulation desired. The conveyor depends on a constant supply of coal from the bin and as the flow is by gravity it is subject to constant variation which results in either a feast or a famine. Mechanically also this feeder is far from desirable as the cheek plates on the conveyor often jam and as these are not easily repaired or replaced a serious interruption results.

(ii) *Mashek Mixers.*

These mixers are horizontal machines steam jacketted and gear driven. As they are completely described in appendix 22 no further description will be given here. Two of these mixers were installed — one being used as the first mixer and the second served as a temperer or cooler, being the last machine in the mixing department. The pitch and coal were mixed in the first mixer, and considerable trouble was experienced due to lack of control of the temperature of the coal entering this machine. The char as discharged from the retorts was partially cooled before being stored in the overhead bin, but owing to the impossibility of controlling this temperature the coal would enter the mixer either too hot or too cold. If the former condition existed the mix would be too dry, and if the latter it would cause the pitch to freeze and form balls in the briquette. It is essential therefore that an extra tempering mixer should be used for regulating the condition of the coal as to moisture and temperature before the binder is added.

The mashek mixers were found to be very satisfactory machines and if the above conditions are observed good results can be expected from their use.

(iii) *Vertical Fluxer.*

This machine has been fully described in appendix 22. It was manufactured by the Traylor Engineering Co. and is used in a number of anthracite briquetting plants and apparently gives good results. It was found at Bienfait that with carbonized lignite it did not approximate the results obtained in anthracite plants. The char requires considerably more binder than anthracite and this makes a heavy mix. As a result it was found that the power consumption was high and that it was impossible to fill the machine to the necessary depth for best mixing. Steam jets are used to raise or maintain the temperature and it was found that this method is not satisfactory. Maximum temperature should be obtained before the pitch is added and there should be a gradual cooling of the mass in the remaining mixers. The use of live steam in the mix after the pitch is added seems to make the mass pasty with resulting trouble at the press.

Judging from the results obtained at Bienfait with this machine it would seem best to eliminate it in future installations.

(iv) *Edge Runner.* (*Masticator*)

In view of the success attending the use of the edge runner in anthracite briquetting plants and the claims made regarding its beneficial action, it was felt that an inclusion of this machine should be made at Bienfait. Tests on the machine previously made at the Nukol plant in Toronto (see appendix 28) showed that considerable crushing is effected in addition to the mixing obtained. As a result of this crushing action it was felt that with a soft material such as lignite char it would supply all the crushing necessary and thus allow of the elimination of roll crushers.

The machine was not found to be satisfactory, however, either as a mixer or as a crusher. It did not give a uniform screen analysis and owing to the loss in temperature in the machine the mix formed into plates which would not break up in the subsequent mixers. These plates result in a weak briquette which splits on leaving the press, and fails to hold its shape in the fire. The edge runner also has a high power consumption and in view of these disadvantages should not be included in an installation of this character.

(v) *Belgian Roll Press.*

The press installed at Bienfait was supplied second hand by the General Briquetting Co. and was manufactured by the Gilley Machinery Co., Gilley, Belgium. As far as the tests at Bienfait are concerned the press seems entirely satisfactory. One criticism which might be made is that there is no provision for taking up the wear on the gears. The wearing down of the gear teeth will cause the pockets of the opposing rolls to be out of alignment and when this occurs it will be necessary to purchase new gears. The method of taking up the wear on the press rolls is by placing shims between the bearing block and the frame which is rather difficult adjustment. The ovoid shaped briquette does not produce as dense a briquette as the pillow shape owing to the pressure not being as great and it would also appear that the percentage of fines due to fins is higher than with the pillow shape.

(vi) *Briquette Handling System.*

The briquette on leaving the press rolls dropped on an inclined metal chute. They were then discharged on a bar shaking screen and by means of a spiral metal chute descended to the cooling table.

This system of handling is entirely too severe for freshly made briquettes, and it was found that a high percentage of breakage occurred as the briquettes struck the inclined metal chute. This was increased at the shaking screen, and still further breakage resulted from the descent to the cooling table.

The briquettes should be removed from the press on a belt and handled extremely gently until they have cooled sufficiently.

(vii) *Binder System.*

The binder system has been fully described in appendix 22. It gave more trouble than any other part of the installation but the trouble was mainly due to the failure to place the supply pump close to the reservoir and provide for gravity feed. When this was corrected the trouble largely ceased but it was found that gravity flow of the pitch from the small overhead tank to the mixer did not give the constant supply as was expected.

In any future installation a pump should be used for supplying the mixer and this should be connected to a variable speed transmission for speed regulation.

(viii) *Belting Trouble.*

A study of Fig. 18 will reveal that a number of vertical drives were used for the mixers. This was more or less inevitable owing to the briquetting building having been erected before the layout was designed, the necessity for such a course of action being fully described in Section VIII of the Secretary's report.

These vertical drives gave a great deal of trouble and a slight overload would result in either belts slipping or coming off. They should therefore be completely avoided in future installations.

(ix) *Dust and Moisture Troubles.*

A duct was provided from all closed machines for the purpose of carrying away the dust and steam incidental to mixing coal and pitch. This installation was satisfactory but the inclusion of the edge runner resulted in considerable dust and steam being present in the building.

The roof of the building was corrugated iron and during cold weather the steam would condense. This made poor working conditions and the moisture increased the troubles with the belts. The excessive dust and moisture resulted in the burning out on one occasion of the 200 H.P. motor which was used for driving the machinery.

To correct these faults a wooden roof should be used and all open machines eliminated.

(x) *Revisions Necessary.*

In order to make this installation workable it is necessary to make the following revisions:—

(*1*) Install positive feeding mechanism at char storage bin.
(*2*) Provide rolls for crushing char.
(*3*) Insert a bin for crushed char.
(*4*) Install accurate feeding mechanism from crushed char bin to mixer.
(*5*) Replace fluxer and edge runner by a horizontal mixer.
(*6*) Correct binder system and install pump for feeding binder to mixer.
(*7*) Correct briquette handling system.
(*8*) Insulate present roof of building to eliminate condensation.
(*9*) Correct drives.

(*g*) POWER HOUSE.

The power house was equipped with three 150 H.P. H.R.T. boilers of Vulcan Iron Works Manufacture. A 400 K.V.A. unit and a 100 K.V.A. unit with a 25 K.W. exciter supplied the electric power for the plant. The former machine was entirely satisfactory but the latter gave continual trouble. It was a very old style engine purchased second hand and was in poor state of repair, consequently the maintenance cost on this unit was high.

It must be remembered that during the years of 1919 and 1920 it was practically impossible to purchase new machinery with the promise of immediate delivery. This condition made it necessary to purchase second hand equipment in order to save time, which accounts for the inclusion of this old style 100 K.V.A. unit.

(*h*) WATER SYSTEM.

The water used in the plant was obtained from the Souris River through an existing pipe line. It was received in a concrete reservoir and pumped to an elevated tank.

Wood stave pipe had been used for distributing the water to the plant and houses. This proved very unsatisfactory as it continually leaked and caused all the pits in the plant to fill with water. The pumping necessary to keep these free of water adds considerable to maintenace costs.

(i) SEWAGE SYSTEM.

A septic tank had been installed to take care of the sewage from the houses and the waste water from the plant. It has never operated to the capacity for which it was designed and shows no indication of being able to attain this. The seepage from the weep drains is a source of annoyance and has caused considerable complaint from the neighbouring mines.

——§——

APPENDIX 24

Recommendations Covering Re-Construction of Carbonizer of Lignite Retort at Bienfait, Saskatchewan.

CHARLES V. McINTIRE
Engineer
66 BROADWAY, NEW YORK
(*Associated with* A. STEPHEN KNOWLES)

January 1, 1922.

BY PRODUCT COKE OVENS
LOW TEMPERATURE COKE PROCESSES
INDUSTRIAL AND COMBUSTION ENGINEERING

R. A. ROSS, ESQ., CHAIRMAN,
The Lignite Utilization Board of Canada,
288 St.James Street,
Montreal, Canada.

Dear Sir:—

Referring to my interview with you of the 22nd ultimo, in regard to your lignite retort at Bienfait, Saskatchewan, I am not yet prepared to report on the coal drier, by-product apparatus or the briquetting system of the plant, but, in order that your re-construction program may be worked out and acted upon at the earliest possible moment, I offer at this writing recommendations concerning the most suitable methods of improving the operating conditions of the lignite carbonizer.

My knowledge of the apparatus and the plant is based upon observations made during one day's stay at the plant at Bienfait, during July, 1921, on behalf of Messrs. Coverdale and Colpitts of New York, and upon information imparted to me by Messrs. Strong, Roche, French and Thomson of your staff during my visit at your office on December 22 and 23, 1921, and is, in brief, as follows:—

1. The mechanical features of the apparatus, which involve the charging of the lignite, its passage over the carbonizing surface and its withdrawal from the discharge gates, now operate satisfactorily. All changes necessary to bring about this result have been completed. The carbonizer has operated continuously over a satisfactory period at the rate of 1200 pounds of carbonized lignite per hour.

2. During the trial runs the gas condensing system was not successfully used for the reason that the gas, after passing through the system and being returned to the carbonizer, was of insufficient quality and of inadequate quality to ignite in the combustion chamber. All of the gases of distillation were allowed to pass directly to the atmosphere through the bleeder pipe.

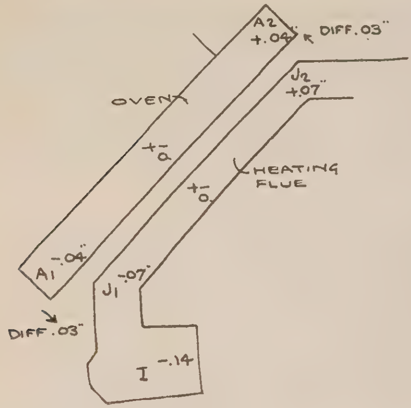
3. With respect to the heating system, the following conditions prevailed: The oil burning system, which supplied the preliminary heating, was satisfactory in part, but did not distribute the heat as desired over the carbonizing surface. The system of heating with distillation gas was not used successfully because sufficient gas was not available. The structure which comprised the heating flues and the air preheating flues was in a leaky condition that permitted the escape of products of combustion into the carbonizing chamber and the passage of air into the combustion flues. The products of combustion were not passed through the coal drier as intended, but were piped directly to the air from the top of the carbonizer.

4. The carbonizing chamber leaked to such an extent that gas escaped to the atmosphere, or air entered the retort as the pressure within varied above or below atmospheric pressure.

While your engineers asked solely for advice concerning ways and means of making the Bienfait carbonizer gas tight, yet, as I pointed out during my visit at your office, such a structure can be made only relatively tight, that cracks, or openings, are likely to appear, and that to obtain satisfactory operating results it is necessary to maintain constant pressure as closely as possible to atmospheric pressure within the retort in order to reduce to a minimum leakage through such cracks. Therefore, before making recommendations for improving the structural features of the oven, I analyze below the factors bearing upon the relation of pressures and the flow of gases in the various compartments comprising the carbonizing apparatus.

The brickwork forming a retort for the carbonization of coal is seldom tight and frequently more or less porous. The carbonizer at Bienfait cannot, in my opinion, be made impervious to the passage of gas; its brickwork will probably be even more permeable than the corresponding parts of an oven or retort which treats bituminous coal of a coking nature, for the bitumens of the latter often deposit carbon on the walls and in the cracks of the brickwork which assist in closing the crevices.

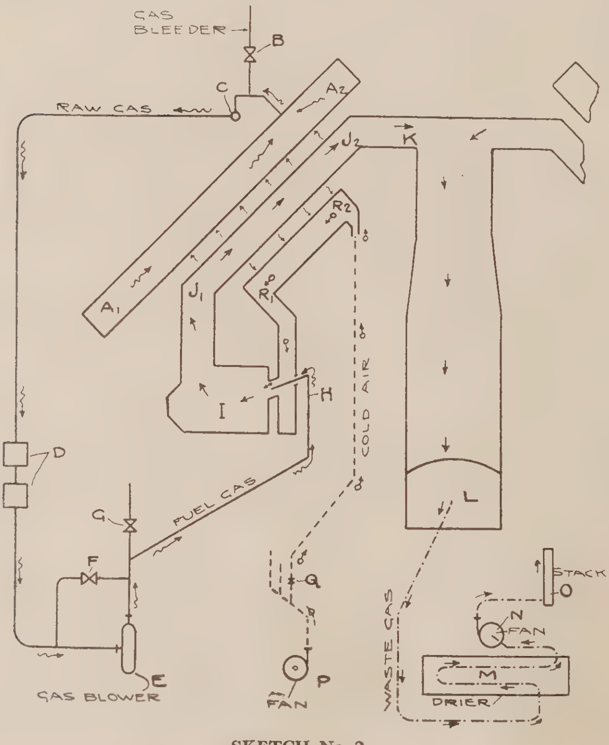
The successful operation of the oven under such conditions requires balanced pressures within the chamber and the combustion flue, and these, I believe, should be about as shown on Sketch No. 1. These pressures are stated in inches water gauge relative to atmospheric pressure at the points indicated and should not be confused with absolute pressures. The pressure at the center of both chambers is shown at zero, while the difference between the average pressure in the top of the oven, A2, and the top of the heating flues, J2, is .03 inch water gauge. The corresponding difference at the bottom is .03 inch water gauge. If in operation it is found desirable to use a high or lower average pressure in the oven, then the flue pressure should be raised or lowered a corresponding amount. The total variation in pressure in either compartment should not exceed .06 inch, or a variation of .03 above or below a given point. Constant fluctuations within the above range may be expected and such fluctuations in the two compartments will not synchronize, which means that at times the extremes of pressures will meet, for example, the pressure, say at A1, will reach —.03 at the moment the pressure at J1 reaches —.10, making a differential of .07 inches.



SKETCH No. 1.

The realization of this desirable balance demands the accurate control of three systems of fans: the gas condensing system, the forced draft fan, and the fan which exhausts the waste products of combustion, all as shown schematically on Sketch No. 2.

The gas pressure within the carbonizing chamber is influenced by the speed of the blower, E, which speed is subject to voltage changes in the electric power; by the operation of the regulator, F; by the cleanliness of the pipe line, C; the scrubbing apparatus, D; and the operation of the valves, B and G; which latter are intended to relieve the system of any surplus gas.



SKETCH No. 2.

In my opinion, the gas condensing system must be altered to include a small gas holder and more sensitive regulating devices.*

The gas pressure within the carbonizing chamber is also influenced by temperature changes, which alter the pressure differential between the bottom, A1, and the top, A2, which differential is caused by the buoyant effect of the heated gases within as compared with the air on the outside.

In the combustion chamber, I, and heating flues, J1 and J2, the pressure is influenced by: variation in the velocity of products of combustion through the heating flues, which is determined by the quantity of gas or oil and air consumed; and variation in temperature which would influence the differential between the bottom, J1 and the top, J2.

It should be noted in this connection that the distribution of the products of combustion must be uniform among the heating flues. Uneven distribution will result in uneven pressures, the hotter flues tending toward reduced pressures at J1, which would, in turn, tend to increase the amount of products entering them and cause further increase in temperature. As a safeguard against such a possibility, I recommend the installation of a regulating damper at the top of each heating flue.

The pressures at J1 and J2 are also influenced by the operation of the fan, H, the temperature of the coal drier and the condition of the ducts leading from point K to the drier and fan.

In my opinion, the waste gas system must include a regulating device to control the pressure. Also it appears necessary to make certain changes in the arrangement of the ducts and fans in order to obtain sufficient draft.**

The pressures within the heating flues, J1 and J2, are also influenced by the operation of the air supply system which includes the fan, P; the regulating damper, Q, the preheating ducts, R1 and R2. Any pressure variations at the fan, which may be caused by voltage changes, atmospheric condition, or other causes, will be felt in the combustion flues. Also temperature variations in the flues will influence the buoyant effect therein, which will affect the downward flow of air resulting in variations in pressure at R1, which in turn will affect I and J1. To avoid such possibility, either the air supply system must be equipped with a suitable pressure regulating device or the present system must be abandoned.

In operation, the air passing through the preheating flues withdraws heat from the combustion flues and returns such heat to the combustion chamber, I, where it is utilized. The air is preheated, but at the expense of the useful heat from the combustion flues. If the heat for preheating the air were withdrawn from the waste products of combustion at some point beyond the carbonizer, as in a recuperator or regenerator, there would be a direct recovery of heat which would be wasted unless provision were made to utilize such heat elsewhere. But the present arrangement contemplates the use of the sensible heat in the products of combustion for heating the coal in the coal drier, a use which will probably require the entire amount available, so any diversion of heat units for preheating the incoming air will not bring about any further economy.

While I am not fully informed as to the temperature requirements for carbonizing lignite in your retort, I understand that the temperature in the lower part of the carbonizer at a point one-half inch above the heating surface should be 1000 F., and I believe that this temperature can be readily attained without the necessity of preheating the air for combustion.

It is therefore apparent that, on account of its influence on pressure conditions, the preheating system cannot be successfully operated without the addition of suitable pressure regulating devices, that the preheating of the air for combustion is not a necessity and that such preheating does not result necessarily in an economy.

In view of the above, I recommend that the preheating system be abandoned, for the present at least, and that the air for combustion be drawn into the combustion chamber by the draft. It may be found advisable to allow a small current of air to pass upward through the preheating flues to prevent overheating the brickwork, which overheating might result in injury to the concrete supporting slab.

If it should develop that suitable temperatures cannot be obtained in the carbonizing surface with cold air in combustion, then it will be necessary either to put the present preheating system into use, (after adding the regulating devices) or to provide some other means for preheating, which means might involve the withdrawal indirectly of heat from the outgoing lignite. The latter method is employed at the plant of the School of Mines, University of North Dakota, at Hebron, N.D., and there is apparently some useful recovery of heat, at least there is no lack of temperature in the combustion flues.

RECOMMENDATIONS COVERING RE-CONSTRUCTION OF CARBONIZER.

Structure of the Carbonizer: To withstand the pressure differential indicated on Sketch No. 1, the design of the brickwork comprising the floor and walls of the carbonizing chamber need not depart from the established practice of retort or coke oven construction.

In the original construction of the carbonizer the heating flues were too wide, the heating floor too thin and the lap joints in the latter could not be kept tight.

For the new construction I recommend that the brickwork be torn out to the base of the preheating flues and re-built in such manner as to provide six heating flues on approximately 12 in. centers. The division walls should be 4 in. to 4½ in. thick, made of special shapes and arranged to interlock or bond with the flanges of the floor tile resting thereon, all as shown on Sketches Nos. 3 and 4. These shapes need not be provided with grooved joints. The inclined partition dividing the combustion flues and the air-heating flues should be at least twice as thick as before and, preferably, should include (if my recommendations for the abandonment of the preheating system are followed) a course of insulating brick marked with dots on Sketch No. 3, such as Silocel. This would result in a reduction in the area of the preheating flues, which reduction I do not consider a disadvantage.

For the floor tile I recommend the use of special shapes made of high grade clay firebrick, the size and arrangement to be about as shown on Sketches Nos. 3 and 4. Each tile should have flanged sides of 4 in. and of 3 in. depth; there should be grooved joints on sides and tongue and groove joints as per Sketch No. 5 on the ends. The flanges should be tapered on the inside and slightly tapered on the outside: the latter would tend to compensate for the spreading which usually occurs in the burning of L or U shaped bricks

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*At the request of Mr. French, I am making definite recommendations for the above alterations in a subsequent report.

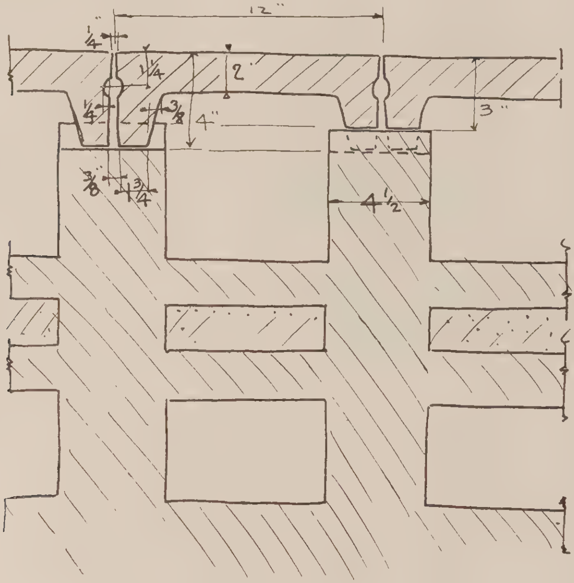
**At the request of Mr. French, I am making definite recommendations for the above alterations in a subsequent report.

The tile should break joints laterally as shown on Sketch No. 4. There should be expansion joints on both sides of the retort, each as shown on Sketch No. 6. These should be filled with sawdust during construction and the joints sealed with pitch to prevent dirt from falling in. The expansion lengthwise of the floor must be taken up by an expansion joint at the top located at a point accessible through the charging hopper. This must be left open until the floor is hot and then pointed up. At intervals during the operation it will need further attention to repair openings caused by temperature changes.

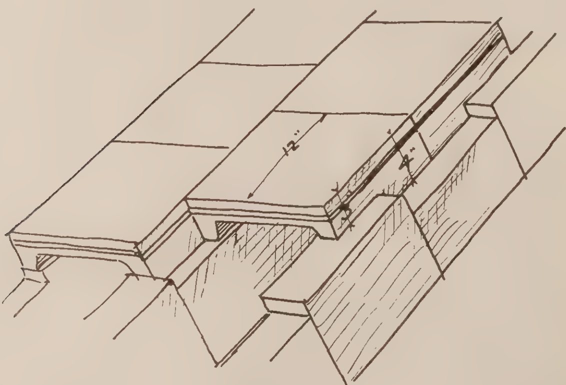
Concerning the quality of tile the following facts should be noted:

The material must not shrink, or grow, at a temperature of 2,500°F.;

The tile are not subject to load;



SKETCH No. 3.



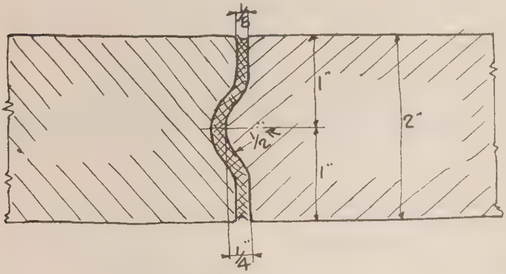
SKETCH No. 4.

They are unusually thin and subject to some abrasion;

The clay for their manufacture should be chosen for its toughness.

I do not recommend brick made of silicon carbide, such as Carbofrax made by the Carborundum Company. My experience with it has been as unsatisfactory as your own, and, while there is promise of the material being perfected in the future, (the manufacturers claim it is now much improved in quality) there

is no reason why you should assume any further risks. Undoubtedly carborundum brick has better heat conducting properties than fire brick, and theoretically this fact should render it desirable for retort heating surfaces, for with a given input of heat units it should require a lower temperature head, or gradient, than fire brick. But it appears that the controlling resistance to the passage of heat is not the heating wall but the coal mass itself, which, being of open granular formation, is a poor conductor, and this condition holds true, in my opinion, for all types of retorts or ovens. Even though the coal in your retort is in turbulent motion, it can not remove heat from the heating surface faster than the refractory material can conduct such heat from the outside. It follows that the temperature heads required for carborundum or fire brick bear no relation to the wide difference in the conductivity of the two materials.



SKETCH No. 5.

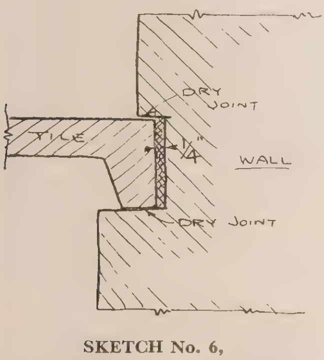
I believe that your retort, if made of fire clay tile, will require somewhat higher flue temperatures, and, therefore, somewhat more fuel gas than it would require if made of carborundum tile, but the total requirement of fuel gas will not exceed the available supply, and the capacity of the retort will not necessarily be reduced.

Calorized metal has not, to my knowledge, been successfully used in carbonization retorts. My experience with the material leads me to believe it will not withstand the temperatures at which your carbonizer is designed to operate and I do not recommend it. But if you desire you might try a few sections of calorized metal in the upper portion of the floor. Preferably such sections should be made approximately the same size and shape as the brick tile and set with rust joints.

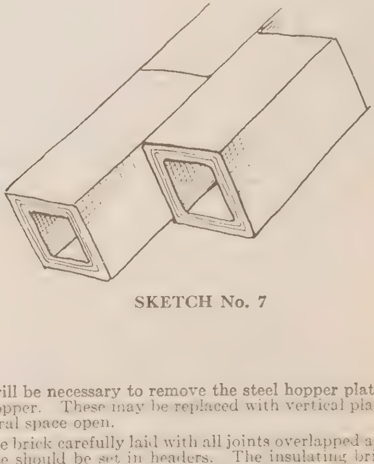
It has been suggested that the combustion flues be made of hollow tile about as shown on Sketch No. 7. This construction, I understand, has been successfully applied for a number of years on Semet-Solvay coke ovens in Europe; also it has been used in the combustion flues of the Dressler Tunnel Kiln, and is said to have given satisfaction. On the other hand, I know of cases where it has failed. There is necessarily a difference in temperature between the top of the flue, which is exposed to the coal, and the bottom, which is backed up by insulating material, and this difference is certain to result in uneven expansion which may lead to distortion and cracks. The shape is difficult to make in high grade fire brick. I do not recommend its use.

Regarding Mr. Thomson's inquiry as to the advisability of abandoning the common combustion chamber, I believe it would be better to arrange an individual heating system for each of the six inclined flues. The present chamber is desirable when burning oil, but it will always be wasteful of heat, and there will always be difficulty distributing the products of combustion into the six inclined flues. For the present, however, since economy of operation is not a factor, and since you desire to re-construct the retorts as quickly as possible, it would be advisable to continue the use of the combustion chamber.

I recommend the installation of regulating dampers, or slide brick, at the upper ends of all combustion flues at point marked K on Sketch No. 2 to permit the adjustment of pressures within the flues. As explained to Mr. French, these can be readily applied by extending the flue division walls and by building an arch over the large downtake flue in which arch will be set holes, approximately 3 in. by 6 in., and upon which holes the slide brick may be set. Access to regulating dampers may be had through suitable openings in the brick work above.



SKETCH No. 6,



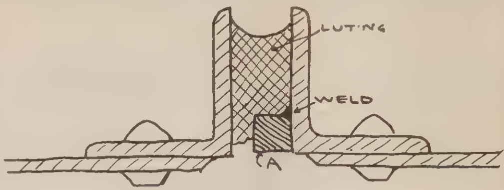
SKETCH No. 7

To install the above dampers and their openings it will be necessary to remove the steel hopper plates, which now form a ridge in the center of the charging hopper. These may be replaced with vertical plates which will form two separate hoppers, leaving the central space open.

The side walls of the oven should be re-built of 9 in. fire brick carefully laid with all joints overlapped and set in Hytempite, or Thermolith, Every second course should be set in headers. The insulating brick now forming a part of the wall should be replaced with fire brick. This construction should be sufficiently tight for your requirements, but undoubtedly cracks will occur from time to time which will require attention.

The leakage in the joints of the cover plates is readily understood, for the thin plates forming the expansion joints are not sufficiently stiff to compress a gasket. A stiffener bar placed on the outside of each joint would probably assist in making the joint tight, but this addition would be difficult and expensive and the removal of plates would always be slow and tedious work. I recommend that the present bolted joints be eliminated and luted joints substituted. This can be done readily by adding a small strip, A, Sketch No. 8, welded to the side of one of the angles of each joint and filling the space with a mixture of red clay and sand, or fine coke. The top of the joint should be washed occasionally with a slurry of clay.

When your draughtsman has finished work on the detail drawings to be made in accordance with my suggestions of December 22, 1921, and along the lines recommended above, I should be glad if you would send a set to me for inspection and comment.



SKETCH No. 8.

In conclusion I might state that if the carbonizer is re-built in accordance with the above recommendations and operated at the pressures approximately as given on Sketch No. 1, and if the by-product apparatus and the waste heat exhausting system are equipped with suitable gas regulating devices as recommended in a supplementary report, the retort should operate as intended. I believe, however, that its capacity will be relatively low, considering the size of apparatus and the cost of construction.

Faithfully yours,

CHARLES V. MCINTIRE.

—§—

APPENDIX 24b

CHARLES V. MCINTIRE
66 Broadway, New York.

January, 6th, 1922.

R. A. Ross, Esq., *Chairman*,
The Lignite Utilization Board of Canada,
288 St. James Street,
Montreal, P. Q.

Dear Sir:—

In accordance with my report of January 2nd, I offer herewith a fuller criticism of the piping and apparatus which comprise the by-product recovery or gas condensing system of your plant at Bienfait, Saskatchewan.

As I have pointed out, the present system can not operate in its present state without setting up unusual and undesirable pressure fluctuations either in the oven chamber or in the line leading to the gas burner, or both. It is a closed system leading from the oven through the by-product equipment, through the blower and back to the combustion chamber of the oven; it is equipped with means for bleeding out a surplus of gas at B and at G, Sketch A, but, since these devices are operated by hand at the discretion of the operators and are not operated automatically, they can not be expected to compensate for any but the most extreme variations in pressure. The by-pass valve, marked F, leading from the discharge side to the suction side of the gas blower is intented to work automatically and will probably do so. It is, however, decidedly limited in range; it can do no more than re-circulate a portion of the gas, which re-circulation will be of absolutely no benefit at times when the supply of gas is greater than the amount needed for combustion. Furthermore, such re-circulation may at times have an effect opposite to the one expected, for it is possible the characteristics of the blower fan are such that an increase in volume of gas handled through the blower may result in an increase instead of a decrease in pressure. The type of automatic apparatus controlling the valve, F, is not sufficiently sensitive to give accurate control even were the above conditions not true.

I recommend changes in the piping system in accordance with a schematic drawing, Sketch A, attached herewith, which changes are briefly described as follows:

(1) Install a gas holder of at least 10,000 cu. ft. capacity and connect it to the gas line at the pressure side of the blower;

(2) Place a bleeder valve at the gas holder operated by the holder bell itself;

(3a) Remove the present by-pass, F, with its governor and install instead a sensitive throttling governor at point T1;

(3b) Place a second sensitive regulator at point T2;

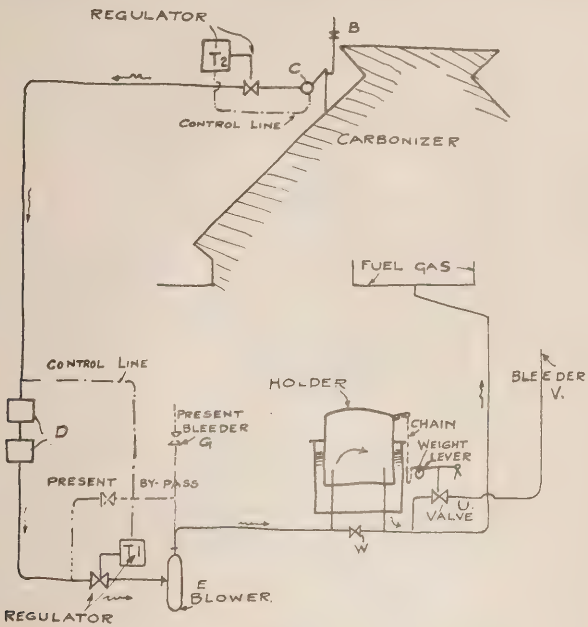
(4) Install a large hydraulic main, GG, to connect all of the carbonizers.

1. *Gas Holder.* — This should be at least 10,000 cu. ft. capacity, erected preferably indoors. Such a location would probably not be convenient at your plant, so adequate provision must be made to prevent freezing — usually a steam pipe arranged to blow jets of steam into the water surrounding the bell is sufficient. If possible, pipe up the holder as shown on Sketch A with all of the gas leading through it. Also provide means in the gas piping to by-pass the holder entirely as at W on Sketch A.

2. *Gas Bleeder.* — The gas bleeder should lead off from the outlet side of the holder to a convenient point away from the buildings. The bleeder valve should be an easily operated gate valve of the quick opening type; it should have a long lever connected by means of a chain to an arm extending from the top of the bell. It should open when the bell reaches within 18 in. of the top of its travel, and it should close by means of a weight when the bell passes the same point on its downward travel. A bleeder of 8 in. diameter should be of ample size.

3. — *Regulators.*

3*a*. — This regulating valve, T1, on Sketch A, should be located at some point in the piping between the centrifugal washer and the suction inlet to the blower, preferably in a horizontal pipe but not necessarily. The valve should be of a butterfly type, of light construction and so arranged as to be readily removed for cleaning and repairs; it should not be larger than 12 in. diameter, and this requirement will make it necessary to install an orifice plate in the gas main (which I believe is 18 in. diameter) which orifice should be placed near the bottom of the pipe to leave a free passage for liquids therein as indicated by the sketches A_1 and A_2.



SKETCH A.

The regulator may be located at any convenient point and connected by means of a rod to the bell crank of the butterfly valve; it must be piped up by a control pipe of about 2 in. diameter to the raw gas line between the regulator, T2, and the first scrubber, D, and must be adjusted to maintain pressure at this point to a total variation of ½″ water gauge, or ¼″ above or below a given point. Its function is to compensate for all fluctuations in pressure set up in the gas lines and the gas scrubber and all fluctuations caused by the fan or blower. I am not familiar with the characteristics of the blower, therefore I am not certain what its performance in this respect would be.

3*b*. — A control valve, T2 on Sketch A, should be located about midway in the 10 ft. horizontal pipe leading to the first scrubber; it should be of the butterfly type, preferably of light cast iron construction, and set with free moving bearings without a stuffing box in a vertical position about as per sketch on next page. It will be noted there is a space below the valve to permit the passage of the flushing liquor

This apparatus should correspond to the "suction main governor" of the coke oven industry. Its function is to throttle the gas leading from the hydraulic main and smooth out pressure fluctuations which may be caused by the regulator, T1; by alterations in temperature in the suction main or the hydraulic main, C; or by changes in the rate of gas production. The machine may be located at a convenient point and connected by means of a rod to the bell crank of the butterfly valve in the suction main. Its control pressure should be piped from a point in the hydraulic main, such as half way between the first and second carbonizers of the battery.

There are several types of regulators, or controllers, or governors suitable for service at T1 and T2, Sketch A, as follows :

The Northwestern Governor manufactured by the Northwestern Manufacturing Company, Milwaukee, Wisconsin, consists of a small bell float, which rising or falling with the fluctuations in gas pressure below it, makes electric contacts and, through relay switches, caused a small motor to turn forward or backward, and this motor is geared to a quadrant which operates a bell crank connected to a similar crank on a butterfly valve in the gas main. It is quite sensitive within certain limits. A recent modification consists of an electrical connection between the suction main governor (corresponding to T2) and the "exhauster governor" (corresponding to T1), by means of which the exhauster governor reaches the extreme of its range, thus the two machines complement one another in an effective manner and there is no hunting. It has given satisfaction in service.

The Tagliabue Governor is made by the C. J. Tagliabue Manufacturing Company, Brooklyn, New York, and is quite simple in all its elements. It consists of a diaphragm valve, called by the manufacturer a

"motor valve", which moves the bell crank of a butterfly valve by pneumatic pressure, a degree of such pressure being controlled by a Tagliabue ball valve working in conjunction with a small float, the latter being moved by the fluctuations in the gas pressure to be regulated. It is similar to the Tagliabue temperature controllers or thermostats.

* * *

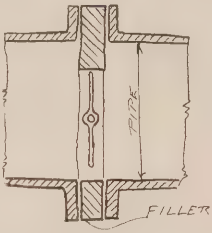
The Smoot Governor manufactured by the Rateau, Battu, Smoot Company, 90 West Street, New York City, is built in several types. The one which would be suitable for your job consists of a pneumatic cylinder, the piston of which is connected by a rod to the bell crank of a butterfly or a balanced globe valve. The pressure supplied to the cylinder is varied to meet the fluctuations in the gas pressure to be regulated by means of an ingenious floating valve connected to a diaphragm. The apparatus will operate on either steam or air but the latter is preferred.

The Koppers Governor. — Its principle of operating is somewhat similar to the Smoot, except that its motor is a hydraulic cylinder; its power is supplied by a small pump running continuously; and its control is by means of relay valves connected to the usual float.

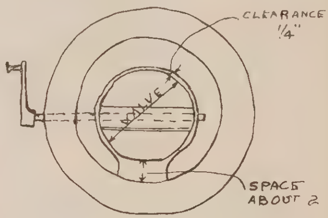
* * *

Any of the above described machines is sold by the manufacturer with a fixed guarantee as to the degree of regulation to be maintained. It is customary to specify a total variation of 2 m/m or 1 m/m above or below a given line.

Of the four regulators above described I recommend the Smoot, for I believe the manufacturer is best equipped to install and adjust the regulators, and I have found the field adjustment to be the most important consideration in the operation of apparatus of this sort. The Smoot apparatus is less expensive (a regulator for your requirements would cost about $300.00 f. o. b. New York) than the Northwestern, but it costs somewhat more than the Taglibue.



SKETCH A 1.



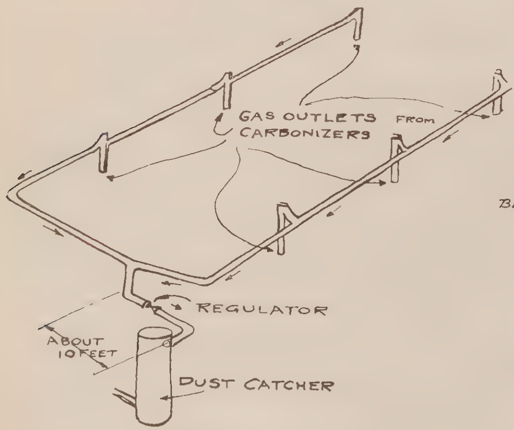
SKETCH A 2.

A further outlay which must be considered in connection with the purchase of a regulator is the charge for the service of an expert to adjust the governor. It would take at least a week at the plant to make the adjustment and the rate would be approximately $10 to $12 a day plus travelling expenses and time of expert while travelling to and from Bienfait.

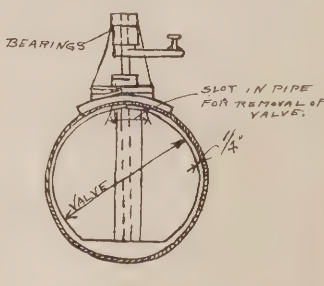
4. *Hydraulic Main.* — In my judgment the present hydraulic main which connects the carbonizers with the by-product apparatus is too small to permit of even distribution of pressure or suction throughout the entire battery. Its rigid construction required the installation of sliding expansion joints at five places and these joints, in my opinion, will always be a source of trouble and will not function as expected.

I recommend the installation of a main of 18 in. diameter in approximately the same location as the present one, but with alterations as follows:

On Sketch B, I have indicated roughly the manner in which I believe the main should be connected to the by-product system; it



SKETCH B.

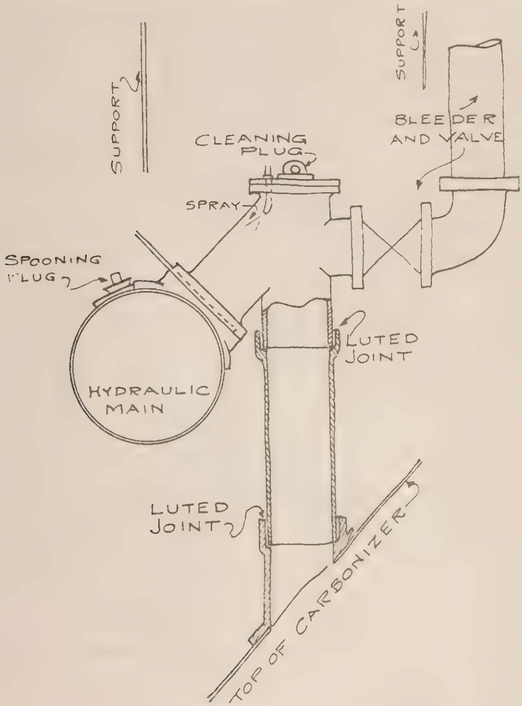


SKETCH A 3.

should slope from the carbonizers at about 3/16 in. per foot; it should connect at the end of the battery with sloping lateral pipes meeting in a T and proceed downwards into a short sloping section leading to the present connection at the dust catcher or scrubber. In this latter section should be placed the butterfly valve of regulator T2. While I have not laid this main to scale on a drawing and am, therefore, not fully apprised of the exact limitations, I believe the above described arrangement would necessitate raising the main a foot or so above the location of the present one. The main may be of light steel construction without expansion joints and supported by hangers in such manner that it may move freely at all points except the point of anchorage, which should be, preferably, in the lateral connection above the butterfly valve. It should be fitted with water sprays at intervals and also with spooning holes of about three in. diameter set at three or four ft. centers, and a platform or gallery should be provided to give access to the latter. I think it would be well to provide a positive flow of tar, or a mixture of tar and

hot water, in the bottom of the main to flush out deposits of dust, but I am not familiar enough with the nature of lignite tar to advise definitely on this point. This is a matter which must be worked out by the operators.

To raise the main from its present location and to permit its free expansion would require a modified standpipe connecting the main with the carbonizers. A desirable design is shown on Sketch C, in which there are two luted bell joints to allow a limited movement. The connection from the vertical pipe to the main should be inclined and there should be a removable plug at the top to give access for cleaning in both directions. A gate valve could be placed at the main, but a simple plate damper such as shown would suffice. The bleeder connection may be taken off at the side as indicated.



SKETCH C.

This suggested construction is in all respects superior to the one you now have, for there is no horizontal run in which dust could settle, and there is not the rigidity of the present one. Its installation would involve a rather expensive alteration requiring the manufacture of special patterns and castings. The most desirable construction, of course, would be in cast iron but, as an alternative, you might consider the building of these six standpipes and their connections of steel pipe by the acetylene welding process, which, if your welder had moderate skill, should be satisfactory and relatively cheap.

Another choice in the construction of a standpipe is furnished on Sketch D, in which the connection to the main is made from your present gas offtake casting by means of standard fittings. This has not the facilities for cleaning possessed by the design proposed in Sketch C, but it is reasonable in cost and has a certain degree of flexibility.

While I have recommended certain definite changes to the hydraulic main and to the standpipes, I realize that your policy, in regard to expenditures and to the amount of time allowed for changes in the plant, may not permit the completion of such an extensive program as I have outlined, and I therefore submit below an alternate program somewhat less comprehensive and less costly.

Install changes Nos. 1, 2, 3a and 3b. They are, in my opinion absolutely essential.

The installation of a larger hydraulic main, as detailed under paragraph 4, while highly desirable, may be postponed. The plant could be operated in a fairly constant manner if the present main were continued in use with its connections altered to include regulating valve F2. With the present main it would be more difficult to maintain uniform pressure conditions on all the carbonizers, but I am not prepared to predict just what the departure from perfect regulation would be. There would be some difficulty in keeping the expansion joints tight.

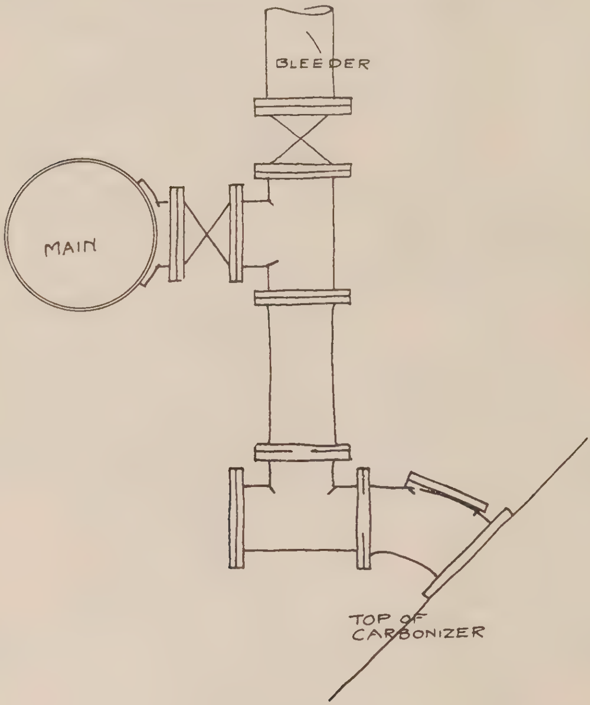
I further recommend the installation of "Hydro" recording gauges such as manufactured by the Bacharach Industrial Instrument Company, Pittsburgh, Pa., as follows:—

To indicate and record the hydraulic main pressure: Two recording gauges with four in. or six in. chart reading in inches or millimeters from zero to minus 10 mm. water gauge and from zero to plus 15 mm. water gauge.

To indicate and record the suction on the raw gas line in front of the dust catcher: One recording gauge with four in. or six in. chart reading zero to 120 mm. water gauge.

To indicate and record the fuel gas pressure: One recording gauge with four in. or six. in. chart to read zero to plus 120 mm. water gauge.

I also recommend the installation of a recording meter to register the quantity of fuel gas consumed, and I believe it would be found desirable also to install a meter to read the total make of gas. For this service either Bailey, Thomas, the venturi meter made by the Builders Iron Foundry, or the Bacharach would be satisfactory. I prefer the latter as it is cheaper than any of the others in first cost and installation cost and sufficiently accurate if its pitot tube or orifice is properly placed in the pipe line.



SKETCH D.

I am not familiar enough with the details of construction of the by-product apparatus at Bienfait to discuss its sufficiency from the standpoint of by-product recovery or gas cleaning. If it is found lacking in this respect the result will be a certain amount of tar in the burner pipes which may prove troublesome until additional apparatus is installed but which should not greatly hinder the operation.

The entire plant as now equipped depends upon the operation of a single blower, and this I consider decidedly a risk. Either an additional blower (preferably a positive blower) should be installed or a ful set of spare parts, such as motor, bearings, rotor, etc., should be carried for making quick repairs on the present apparatus.

Sincerely yours,

(*Signed*) CHARLES V. MCINTIRE.

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APPENDIX 25

Record of Tar Distillations — Small Tar Still.

By R. A. STRONG.

During the operations of the Hood-Odell shaft carbonizer at Bienfait, a large quantity of tar was recovered, and laboratory tests were made on small samples the results of which are given in Appendix 27.

In order to determine whether the tar would present any serious difficulties in distilling and whether the pitch obtained would be suitable for a binder, it was decided to erect a small still, and distill enough tar to provide the pitch binder necessary to briquette a car load of char. The lignite pitch was to be mixed with coal tar pitch in the proportion of one part of lignite pitch to 3 parts of coal tar pitch, as it was estimated that in commercial operation only 25% of the binder requirements could be met by the pitch obtained from the lignite tar. A number of tar distillations were, therefore, made. The pitch received was forwarded to Hebron for the briquetting test, and the oils were sent to the laboratories of the Department of Mines, Ottawa, in order that they might be analyzed and a test made as to their applicability as a fuel for a semi-Diesel type of engine. The results of the briquetting test with the lignite pitch are given in Appendix 30, and an analysis of the oils, made by the Department of Mines, appears in Appendix 27. Unfortunately at date of writing the Diesel engine test has not yet been completed.

In order to carry out the distillations a small tar still was constructed from an old 40 gallon gasolene drum. The drum was set horizontally in brick work, and insulated with magnesia. Brick checker work was used in the combustion chamber, and a 2″ line was piped from the gas supply line for fuel. A 2″ off-take was provided which was connected to a 2″ pipe, water jacketed, serving as a condenser. Provision was made for inserting a thermometer at the offtake in order to observe temperatures, and to control the quality of the pitch. The drum was placed at a slight inclination from the horizontal and a small pipe with a cast iron cock was used for draining the pitch from the drum after the distillation was completed. The tar was taken from the tar storage tanks, but was not a representative sample of the total tar recovered, as considerable condensation naturally had taken place at the water seal and at other places along the line before the gas reached the wet scrubber. As taken from the tanks, the tar was in the form of an emulsion containing approximately 70% of water. Heating had no effect in breaking up this emulsion, and in order to get the water content down to 30%, it was necessary to cool the tar, work it with a paddle, and pour off the liberated water as it appeared. In commercial operation of this character, it would be necessary to recover the tar in such a way as to avoid these emulsion difficulties. In the first attempts at operating the still no record was kept of the time required to bring the temperature to the desired point, and as a result considerable variation in the melting point of the pitch was found. In subsequent operations, the temperature was raised to the desired point in a definite time, and as a result very uniform pitch was obtained. It was found that to approximate a pitch of 140°F melting point the distillation had to be stopped at 265°C., with a distilling time of 75 minutes.

A record was kept as to the quantity of gas required to complete a distillation, and from the results obtained it is safe to assume that with a tar emulsion carrying 30% of water 5,000 cu. ft. of gas of 100 B. T. U. is required to distill 100 lbs. These figures are of course only applicabie to the small installation used, and could be materially reduced in a properly designed still of larger dimensions.

The oil as recovered has an average density of 0.965, and has a decidedly objectionable odour of hydrogen sulphide. It shows no signs of congealing at ordinary temperatures and from all appearances would make an acceptable fuel oil. The pitch is somewhat different in appearance to coal tar pitch, being more oily. It has a dull lustre and somewhat resembles asphaltum.

A total of 1,715 lbs. of tar was distilled having an average water content of 32.1%. This yielded a total of 1,200 lbs. of pitch (with average melting point of 145° F.) which is a 70.0% yield on the dried tar basis.

The record of a number of these distillations is included below as a matter of interest. The conclusions to be drawn from the tests are that no difficulty is to be expected in converting the tar into oils and pitch provided proper methods are followed in recovering the tar, in order to eliminate as much as possible the formation of persistent emulsions. It is quite difficult to distill tar with 30% of water without having it froth over but by practice and careful observation it can be accomplished. It is desirable, however, to reduce the water content of the tar to a minimum.

DISTILLATION RESULTS.

1st Distillation

Weights not recorded.

2nd Distillation

Cut at 260 degrees — Taken up slowly.

Tar	72.25 lbs.	......	......
Water	21.45	29.5%	......
Oil	11.45	15.7%	22.3%
Pitch	34.00	46.8%	66.4%
Loss	5.85	8.0%	11.3%

M. P. pitch 150 degrees F.

3rd Distillation

Cut at 260 degrees F.

Tar	71.25 lbs.	......	......
Water	25.53	35.8%	......
Oil	9.59	13.5%	21.1%
Pitch	34.75	48.8%	76.1%
Loss	1.38	1.9%	2.8%

Gravity of oil 0.965.

M. P. of pitch 138 degrees F.

4th Distillation

Cut at 260 degrees F.

Tar	69.00 lbs.	......	......
Water	25.65	37.2%	......
Oil	9.10	13.2	21.1%
Pitch	32.50	47.1	75.0
Loss	1.75	2.5	3.9

Gravity of oil 0.965.
M. P. of pitch 138 degrees F.

5th Distillation
Cut at 270 degrees F.

Tar	60.00 lbs.	......	......
Water	19.12	31.9%	......
Oil	10.63	17.7%	26.0%
Pitch	27.00	45.0%	66.1%
Loss	3.25	5.4%	7.9%

M. P. pitch 144 degrees F.

6th Distillation
Cut at 270 degrees F.

Tar	67.00 lbs.	......	......
Water	21.10	31.5%	......
Oil	12.65	18.9%	27.6%
Pitch	32.25	48.2%	70.4%
Loss	1.00	1.4%	2.0%

M. P. of pitch 153 degrees F.

7th Distillation
Cut at 270 degrees F.

Tar	66.25 lbs.	......	......
Water	20.33	30.7%	......
Oil	11.67	17.6%	25.4%
Pitch	30.00	45.3%	65.4%
Loss	4.25	6.4%	9.2%

M. P. of pitch 147 degrees F.

8th Distillation
Cut at 270 degrees F.

Tar	73.75 lbs.	......	......
Water	24.06	32.6%	......
Oil	11.94	16.2	24.1%
Pitch	34.00	46.1	68.4
Loss	3.75	5.1	7.5

M. P. of pitch 153 degrees F.

9th Distillation

Tar	85.00 lbs.	......	......
Water	25.07	29.5%	......
Oil	15.43	18.2%	25.8%
Pitch	43.00	50.6%	71.8%
Loss	1.50	1.7%	2.4%

M. P. of pitch 147 degrees F.
Density of oil 0.965

10th Distillation
Cut at 265 degrees F. — Time 58 min.

Tar	81.00 lbs.	......	......
Water	23.77	29.3%	......
Oil	12.98	16.0%	22.6%
Pitch	42.00	51.9%	73.5%
Loss	2.25	2.8%	3.9%

M. P. of pitch 136 degrees F.
Density of oil. 0.965

11th Distillation
Cut at 270 degrees F. — Time 1 hour

Tar	72.00 lbs.	......	......
Water	23.45	32.6%	......
Oil	12.55	17.4%	25.8%
Pitch	33.00	45.8%	68.0%
Loss	3.00	4.2%	6.2%

M. P. of pitch 149 degrees F.
Density of oil 0.965

12th Distillation
Cut at 269 Degrees F. — Time 59 min.

Tar	79.00 lbs.	......	......
Water	23.19	29.3%	......
Oil	13.81	17.5%	24.8%
Pitch	40.00	50.7%	71.7%
Loss	2.00	2.5%	3.5%

M. P. of pitch 147 degrees F.
Density of oil 0.965.

13th DISTILLATION

Cut at 271 Degrees F.—Time 45 min.

Tar	80.00 lbs.	......	......
Water	24.55	30.6%	......
Oil	14.20	17.8%	25.7%
Pitch	38.00	47.5%	68.4%
Loss	3.25	4.1%	5.9%

M. P. of pitch 154 degrees F.

14th DISTILLATION

Cut at 265 degrees — Time 75 min.

Tar	75.50 lbs.	......	......
Water	23.97	31.7%	......
Oil	11.03	14.6%	21.3%
Pitch	39.25	52.0%	76.2%
Loss	1.25	1.7%	2.5%

M. P. of pitch 142 degrees F.
Density of oil 0.965.

15th DISTILLATION

Cut at 265 degrees — Time 75 min.

Tar	83.25 lbs.	......	......
Water	31.12	37.4%	......
Oil and Loss	14.13	17.0%	27.2%
Pitch	38.00	45.6%	72.8%

M. P. of pitch 142 degrees F.

DISTILLATION FRACTIONS

0 °C 110 °C	690 C.C.	0.950 density	12.3% by weight
110 — 170 —	285 "	0.965 "	5.2% " "
170 — 200 —	555 "	0.980 "	10.2% " "
200 — 210 —	280 "	0.975 "	5.1% " "
210 — 235 —	575 "	0.975 "	10.6% " "
235 — 265 —	3,083 "	0.975 "	56.6% " "
	5,468 "		100.0%

DISTILLATION No. 16.

Cut at 265 degrees — time 80 minutes

Tar	77.00 lbs.	......	......
Water	19.75	25.7%	......
Oil	12.00	15.6%	20.9%
Pitch	40.00	51.9%	69.9%
Loss	5.25	6.8%	9.2%

M. P. of pitch 138 degrees F.

DISTILLATION No. 17

Cut at 265 degrees — Time 70 minutes

Tar	93.00 lbs.	......	......
Water	25.50	27.4%	......
Oil	15.50	16.7%	23.0%
Pitch	47.00	50.5%	69.6%
Loss	5.00	5.4%	7.4%

M. P. of pitch 138 degrees F.

DISTILLATION No. 18

Cut at 265 degrees — Time 76 minutes

Tar	89.50 lbs.	......	......
Water	24.25	27.1%	......
Oil	15.25	17.0%	23.3%
Pitch	50.00	55.9%	76.7%

M. P. of pitch 140 degrees F.

DISTILLATION No. 19.

Cut at 266 degrees — Time 70 minutes

Tar	95.50 lbs.	......	......
Water	24.50	25.6%	......
Oil	17.00	17.8%	23.9%
Pitch	49.75	52.1%	70.1%
Loss	4.25	4.5%	6.0%

M. P. of pitch 138 degrees F.

DISTILLATION No. 20.
Cut at 265 degrees — Time 74 minutes

Tar	92.50 lbs.	......	......
Water	24.00	25.9%	......
Oil	17.25	18.7%	25.2%
Pitch	47.50	51.3%	69.3%
Loss	3.75	4.1%	5.5%

M. P. of pitch 138 degrees F.

DISTILLATION No. 21.

Tar	75.25 lbs.	......	......
Water	23.00	30.6%	......
Oil	19.00	25.2%	36.3%
Pitch	33.25	44.2%	63.7%

Approximately 5,000 cu. ft. gas required to complete distillation.
M. P. of pitch 156 degrees F.

DISTILLATION No. 22.
Cut at 267 degrees F. — Time 66 min.

Tar	81.25 lbs.	......	......
Water	21.50	26.5%	......
Oil	16.50	20.3%	27.7%
Pitch	38.50	47.3%	64.3%
Loss	4.75	5.9%	8.0%

DISTILLATION No. 23.

Tar	81.75 lbs.	......	......
Water	15.50	19.0%	......
Oil	13.00	15.9%	19.6%
Pitch	43.25	52.9%	65.4%
Loss	10.00	12.2%	15.0%

DISTILLATION No. 24.
Cut at 266 degrees F. — Time 70 min.

Tar	81.00 lbs.	......	......
Water	21.50	26.5%	......
Oil	13.25	16.3%	22.2%
Pitch	41.50	51.3%	69.8%
Loss	4.75	5.9%	8.0%

DISTILLATION No. 25
Cut at 266 degrees F. — Time 72 min.

Tar	94.00 lbs.	......	......
Water	25.50	27.1%	......
Oil	17.00	18.1%	24.8%
Pitch	48.25	51.3%	70.4%
Loss	3.25	3.5%	4.8%

DISTILLATION No. 26.
Cut at 266 degrees F. — No time record.

Tar	99.00 lbs.	......	......
Water	23.25	23.5%	......
Oil	20.00	20.2%	26.4%
Pitch	54.50	55.1%	72.0%
Loss	1.25	1.2%	1.6%

—§—

APPENDIX 26

Details of Trial Runs during 1922 of Stansfield Carbonizers, Bienfait, Sask.

By R. A. STRONG.

During the operation of the Stansfield carbonizers, at Bienfait, detailed reports were prepared which outlined the troubles encountered. These reports were in log form and as they report day by day impressions, uncoloured by the perspective which time sometimes gives, a few typical ones have been selected as being of some interest.

In explanation of the terms used, it should be stated that a number of thermo couples had been inserted through the cover plate of the retort, the ends resting in the moving stream of lignite, thus recording the coal temperatures within the retort at different locations. A row of these thermo couples was placed

toward the lower end of the retort, another row at the centre and still another row close to the upper end. In the following logs these locations are referred to as bottom, centre and top. In the same localities provision was made for obtaining pressures, the connections being carried to Bacharach recording gauges or homemade inclined gauges, sensitive to 100th of an inch water pressure and these are referred to in a similar manner.

The letter used in connection with the baffles has reference to their design. Originally there were four different types of baffles used, called A, B, C, D. The A baffles had 1½″ of clearance, the B 1¼″, the C 1″ and the D ¾″. The trouble caused by fines which is discussed in appendix 23, led to a new design of baffle designated as E. These baffles were not as high as the previous ones and had only ½″ of clearance

BIENFAIT, SASK., *Sept. 14th, 1922.*

CARBONIZER TRIAL RUN SEPTEMBER 8th, 1922, RUN "D. 1″.

Started heating retort number one with wood and coke at 6 p.m. September 6th, in order to warm up gradually. This retort is built with the new carbofrax hollow shapes, and was assembled with one row of "D" baffles, three rows of "C" baffles, cut to 7-½ inches, 56 rows of "E" baffles; 2 rows of "A" baffles cut down to about 5″ were used at the top and one inch clearance remained between the last row of baffles and the hopper plate.

This gradual heating was continued throughout the night of Sept. 6th and for the following 24 hours, using an occasional oil flame, until Friday, September 8th. Carbonized coal was fed to the retort at 1.40 p. m. and at 1.55 p. m. the discharge was started at the rate of about 12 pounds per minute or 8 tons per 24 hours.

The temperatures at the time coal was fed were as follows:—

Bottom	100 degrees F.		
Centre	505	"	"
Top	350	"	"

The gas was allowed to escape to the atmosphere through the bleeder pipe. At 3.45 the oil pipe burst which caused the oil to be shut off for 30 minutes while this was being repaired.

From the start No. 6 discharge gave trouble, it being about one half the capacity of No. 5. This was unexplainable as both impellors are presumably the same dimensions and connected to the same shaft. This difficulty caused number six channel to become very much hotter than the rest of the retort. Tried reversing the direction of rotation but this did not overcome the difficulty and at 7 p. m. decided to shut down and change to another discharge chute.

Shut the oil off and started to empty the retort. At this time the temperatures were as follows:—

Bottom	940 degrees F.		
Centre	720	"	"
Top	290	"	"

At 7.30 noticed temperature in number 5 and 6 channels mounting rapidly and found cover plate to be red hot. The pyrometer registered around 1,300 degrees F. Started discharging more rapidly by hand and succeeded in bringing the temperatures down considerably but not as much as we should have done. Decided the coal was on fire in the retort but sample of discharge showed no signs of burning. Evidence pointed to the gas being on fire and proceeded to look for leaks. The pressure at the bottom of the retort was—.03″ and as the luting around the expansion joints was badly cracked presumed the leaks to be there. Reluted this section and the temperature immediately dropped.

During the night changed the discharge chute ready to start the following morning. The change in the chutes caused No. 5 to feed slower than No. 6 but this was not considered serious enough to prevent another attempt.

There is a new type of expansion joint where the above mentioned leak occurred, consisting of overlapping angles covered with fireclay luting. With dried coal there would have been more gas and a positive pressure on the retort but with the carbonized material there was a decided suction which with the leaky condition of the cover accounted for the fire.

(*Signed*) R. A. STRONG.

September 21st, 1922.

TRIAL RUN ON CARBONIZER No. "D-2" SEPTEMBER 9th 1922.

During the night of September 8th, changed discharge as mentioned in previous journal and turned on the oil at 9.20 a. m. Sept. 9th. The retort had not cooled entirely and the temperatures at time of starting were as follows:

Bottom	180° F.
Center	410° F.
Top	380° F.

Continued heating slowly until 11.15 a.m. and then fed carbonized coal to hopper. The discharge at this time was fairly uniform but No. 6 channel was slightly faster than No. 5. At 1.25 p.m. fed dried coal in hopper, average temperatures and pressures at this time were as follows:

Bottom	720° F. — 0.06″ water gauge.	
Middle	640° F. — 0.03″ water	"
Top	290° F. — 0.01″ water.	"

At 2.10 p.m. the suction still being rather high, closed bleeder valve at gas holder which had been open in order to purge the line when exhauster was turned on. This caused a decrease in the suction but it soon increased again and tried closing butterfly valve but as this had no effect closed bleeder valve at offtake partially, which raised the pressure. At 4.30 p.m. the gas collected in a sample bottle was found to be combustible but exhauster was not turned on until 5.55 p.m.

All previous attempts at adjusting the new regulators had proved futile, but with the gas in the system found that one of them functioned fairly well. The other failed to operate and was discontinued and the valve opened. Changes in average gas flow from time to time were corrected for by means of a hand operated valve on the pressure side of exhauster. By way of comment the regulator which operated gave sufficient evidence of its worth and with two in operation it may be expected that the pressure can be maintained fairly uniform. The regulators are rather complicated mechanically and after a few attempts to adjust them it was thought better to have an expert do the job and a telegram to this effect was sent off to the company.

After starting the exhauster the gas lines and holder were thoroughly purged of all air and then the gas allowed to go into the holder. At 6.40 p.m. the gas was turned on at the burners and the oil extinguished. Oil and gas was burned alternately throughout the night. The gas holder was filled during the oil burning periods and emptied during the gas burning periods.

Operation was fairly smooth and pressures were maintained fairly constant throughout the night. From 4.00 a.m. to 7.30 a.m. the pressures were exceptionnally uniform and operation was very smooth. At 7.30 a.m. the pressures gradually increased and operation became very erratic. This followed an increase of the operating temperatures in the carbonizer. The valve on pressure side of fan which had been used to regulate the flow of gas had been gradually opened as the pressure on the carbonizer increased. At 10.30 a.m. this was wide open and the pressure was still too great. This indicated a block in the line. The leaks in the cover plates during these high pressure periods were allowing large volumes of gas to escape into the building and this became so thick in the room that the operators could not stay at their posts. In order to relieve this situation it was necessary to open the bleeder partially to relieve the pressure. Tested the line for blocks and found slight pressure on dust trap and scrubber, on the suction side of exhauster. No gas seemed to be coming through, which indicated a block beyond the fan. At 10.55 a.m. opened bleeder and cut off fan. Took out 4″ diaphragm and found it quite clear. Replaced it with 8″ and inspected valve on pressure side of fan but found this quite clear. At 1.00 p.m. started fan up again but experienced the same difficulty of operation and at 2.00 p.m. resorted to bleeder.

During this latter period the temperatures were quite high averaging over 1100 degrees F. and it was the intention to speed up the discharge to see if sufficient gas to maintain the temperature could be obtained. The discharge was accordingly increased to 1100 pounds residue per hour. Owing to the difficulty of operation this experiment was abandoned and the original setting was resumed.

The exhauster fan had not been examined, so this was done and was found to be about one quarter full of tar and water. It was necessary to blow this out as no drains had been provided. An inch or so of heavy tar remained which was impossible to get out.

At 5 p.m. started fan again, after having changed back to 4″ orifice for flow meter. Irregular operation was still experienced and as the supply of dried coal had been exhausted it was considered advisable to shut down. This was done about 6.00 p.m.

During this run no complete record was kept as to the oil and gas consumed, but there was not nearly enough gas generated to run the carbonizer. The discharge was considerably under the estimated capacity of the carbonizers and the average temperature was never much above 1000 degrees F. An increase in one or both these factors might increase the yield of gas until it was sufficient. This will be determined in the later trials.

At one stage of the run, when the pressure at the carbonizer offtake was approximately atmosphere, with slight suction at the bottom and pressure at the top, the gas was found to contain 8% of oxygen due to leaks.

Later on, after repeated luting of all the joints, the cover was made more nearly gas tight, a slightly increased pressure was maintained and the oxygen content was reduced to about 1-½%. During the period when the gas was not removed from the carbonizer as fast as made it was impossible to maintain tight joints by luting. The movement of the charge through the carbonizer was perfectly regular throughout the entire run. No indication of any leak between combustion and carbonizer flues could be observed.

During a period of 14-½ hours of regular operation the retort was heated by gas for 62% of the time and by oil for 38%. This gives an indication of the extent to which the gas produced would be insufficient to heat the retort under the conditions of operation employed in this run. Owing to the lag in temperature readings it is difficult to determine whether the retort was heated equally during gas and oil firing periods.

(*Signed*) R. A. STRONG.

BIENFAIT, SASK., *September 22nd, 1922*

CARBONIZER TRIAL RUN No. "D-3" SEPTEMBER 15TH., 1922.

Before attempting another run it was necessary to make some improvements in the jointing of the cover plates as the gas leaks referred to in journal sheets of run D-2 were very annoying and dangerous to operators. It was decided to make channels of sheet iron about 18″ high running along each joint. These were to be filled with sand. A constant depth of sand on the longitudinal joint was maintained by means of baffles. Several days were occupied in making this alteration and in the meantime a dryer was operated as the supply of dried coal had been exhausted during the previous run.

Several other changes were made during this shut down which seemed necessary from experience gained in the previous run. These changes consisted of the following.

1. — Adjustable blades were put on impellors Nos. 5 and 6 in order to correct for unevenness in discharge.

2. — Changed tee at exhauster fan to an elbow in order to allow fan to blow out accumulation of tar and water.

3. — Put drain in exhauster for tar removal.

4. — Moved valve on pressure side of exhauster to a position in front of control house to allow tar to settle before reaching valve.

5. — Put drain on pressure side of exhauster behind valve.

6. — Put gauge on pressure side of exhauster also test burner.

7. — Put pyrometer couple in combustion flue.

8. — Put gauges on combustion chamber and downtake.

During the night of September 14th., heated the carbonizer with wood and coal and started charging the following morning at 10.15 a.m. Dried coal was charged at noon.

At 7.20 the exhauster was turned on. Very irregular pressures were experienced during this run as soon as the gas was turned into the purifying system, and in order to operated it was necessary for one man to continually operate the hand valve on the pressure side of exhauster. The regulator continued to function but would fail to check either big increases or decreases in pressure. This meant that the flow of gas was so small that it could all pass through the clearance between the valve and the diaphragm. In the previous run the leaky condition of the cover plates had acted as a regulator allowing air to be drawn in when the retort was under suction and gas to escape when it was under pressure. Evidence also pointed to a block in the gas lines. At 9.15 the exhauster was turned off in order to put gauge connections at suction inlet to fan also between scrubber and fan. Opened scrubber and found everything quite clear and free from tar. At 11.00 turned on exhauster again and took readings at new gauge connections. Found the suction to be practically negligable and no improvement in operating conditions so opened bleeder valve at 11.15 and discontinued run.

In this run as in the two preceding ones the mechanical operation of the retort itself left small room for improvement. The flow of coal through the retort was uniform and no evidence of any irregularity in feeding hopper was noticed. The coal used is of a slightly coarser screen analysis than that used in last year's trial runs, but is still much finer than was used in the model carbonizer at Ottawa.

(*Signed*) R. A. STRONG.

BIENFAIT, SASK., SEPTEMBER 23RD, 1922.

CARBONIZER TRIAL RUN NUMBER "D-4" SEPTEMBER 18TH, 1922.

As mentioned in the journal of the previous run, the damper valves had been found to have too much clearance when shut which allowed the small amount of gas obtained when operating one retort to pass through. Under these conditions the regulators could not be expected to do any real regulating. A ten inch valve had been placed in the line from the scrubber to the fan and for one retort this was considered too large. Both valves were removed and the clearance reduced. A six inch valve was used to replace the ten inch. The following day (Sunday), Mr. King the expert from the Rateau Battu Smoot Co. arrived and several tests were made as to the drop in pressure across the valves, using air instead of gas. There was still too much clearance and during the night the valves were again removed and this reduced to a minimum. A fire was also built in the retort and preparations made for a run the following day. Continued this heating with occasional periods of oil until 12.30 p.m. Sept. 18th, and then charged carbonized coal. At 3.10 p.m. dried coal was charged in feeding hopper. At this time the temperatures and pressures were as follows:—

Bottom	880	degrees	F. — .05″	water gauge
Middle	670	"	F. — .00″	" "
Top	300	"	F. plus .03″	" "

The temperatures continued to rise for a short time but at 5.00 p.m. started to fall and although the oi was full on the decline could not be checked until 8.00 p.m. The discharge was at a somewhat larger rate than previously which probably accounts for this drop in temperature shortly after the introduction of the dried coal. This gives an indication of the heat required for carbonization of green coal. The drafts were also very bad owing to the brickwork leading to the stack being quite cold. This improved as the brickwork became hotter. At 8.00 p.m. the exhauster was turned on and all the gas lines and holder purged of air. At 8.45 the gas was turned into the retort to augment the oil burner and from then on the temperatures rose.

Mr. King made several adjustments on the regulator nearest the retort and at midnight had it functioning perfectly. The pressure variations during the night did not vary more than a millimeter. The second regulator had not been adjusted and this was left until the morning when it was expected that with higher temperatures a bigger flow of gas would give a sufficient drop in pressure across the valve to allow the regulator to function.

Gas and oil were burned alternately during the night and records kept of the time each was on. A record of production of gas was kept by observing the height of holder at given intervals Flue gas samples were taken and analyzed during gas burning periods in order to regulate the amount of air admitted through the explosion door. No conclusive information was gained in this connection.

From midnight until 10.30 a.m. September 19th, operation was very regular and smooth leaving little to be desired. The gas generated was insufficient for the requirements of the retort averaging slightly over 50%. The methods of measuring were however not sufficiently accurate to accept this figure as final. With continued operation the heat requirements may be considerably reduced and with an increase in the discharge more gas can be obtained. At present it is sufficient to say the retorts were not self sustaining.

At 10.30 a.m. the temperature had risen to over 1000 degrees and operation immediately became very irregular. The exhauster appeared unable to remove the increased quantity of gas. At 11.30 the discharge was increased on number 5 and 6 as these channels were becoming quite hot being over 1200 degrees F. The average temperature at the bottom of the retort at this time was 1120°F. The temperatures started dropping almost immediately. During this period the voltage of the fan was tested and found to be in the vicinity of 550. The speed was 1807 r.p.m. At noon the gas was sent through the bleeder valve and the fan stopped for three minutes. Tested drain cocks for tar accumulation but found none. The suction increased slightly immediately after starting fan again but the improvement was only temporary. It should be noted that the control valve on pressure side was at this time full open as well as two six inch damper valves. The temperature of the gas was taken at the fan and found to be around 40 degrees C. At 3.15 cut down the discharge in order to decrease gas volume and cut down gas burners to lower temperature. The failure of the fan had upset all regulation, and at 5.00 p.m. it was decided to discontinue run and dismantle fan. This was done and the fan was found to be in perfect condition and with very little tar in it. A telegram was then sent to the makers.

During the morning of September 19th, the supply of dried coal was becoming low so a fire was started in the east dryer. The suction in the combustion chamber and downtake immediately increased. Coal

was fed to dryer at one o'clock. For a short time during the afternoon the damper to west dryer was closed and the hot combustion gases confined to the east dryer. Prior to this the gases had been sent through the west dryer. The suction decreased but no difficulty was experienced in getting sufficient draft. This was the first attempt at operating a dryer and carbonizer simultaneously. It was not continued long enough to draw any certain conclusions, but gave no indication that difficulty will be encountered.

This run is the first in which flushing liquor was used in foul gas mains also spray employed in the dust trap. It resulted in a large percentage of the tar separating at the dust trap from where it passes to the sewage system. Steps must be taken to prevent this loss of tar and damage to sewage plant.

With regard to the failure of the exhauster to handle the hot gases in any quantity it might be noted that high temperatures in the carbonizer have been obtained before without resulting trouble but in such cases a lower rate of discharge was used. Also higher discharges have been employed with lower temperatures but it is now clear that trouble was always experienced when the gas output became notably increased. As the gas flow increases as indicated by flow meter, the suction behind the exhauster gradually decreases to zero, and in some cases even a slight pressure from the carbonizers was registered there. This clearly indicates that earlier idea of a tar block in the system was entirely erronous.

(*Signed*) R. A. STRONG.

BIENFAIT, SASK., OCTOBER 7TH, 1922.

CARBONIZER TRIAL RUN "D-5" SEPTEMBER 25TH, TO 30TH, 1922.

SEPTEMBER 25TH.

Heated carbonizer during Sunday and Sunday night with wood, and at 1.20 p.m. Sept. 25th, turned on the oil. Carbonized coal was fed into the retort at 4.15 p.m. at which time the average temperature across the center of the retort was 850°F.

On Saturday night previous to the run had thoroughly tested out fan and found that the maximum resistance overcome was over 8″ and that the volume delivered was not materially affected by either increasing or decreasing the back pressure. As stated in previous journal the 8″ orifice for flow meter had been changed to a 4″ in order to increase the reading of the flow chart. This was changed again and the 8″ orifice replaced. With the two 6″ regulating valves open the fan delivered 25,980 cu. ft. of air per hour against a pressure of 7.42 inches and a suction of 2.0 inches. The scrubber was opened in order to eliminate one of the regulating valves and with the bleeder at the holder open the fan delivered 70,800 cu. ft. of air per hour against a pressure of 3.05 inches and a suction of 5.6 inches. The hand control valve on the pressure line could not be opened full as the reading otherwise could not have been contained on the flow meter chart. It was decided to leave the 8″ orifice in during the run as the flow was increased thereby and it was hoped that this increase would allow operating at higher temperatures and with a bigger discharge.

A 6″ orifice was placed in the line leading from the holder to the burners and the flow meter connected in order to read directly the gas consumption.

At 7.55 p.m. the dried coal was fed to the retort and although the discharge had been materially decreased from the previous run the temperatures dropped as soon as the dried coal got into the retort and were very erratic until 10.30 p.m.

At 9.10 p.m. the exhauster was turned on and no trouble was experienced until 12.00 midnight. One of the middle thermo couples at this time showed a big increase in temperature, being 940 degrees F. The discharge was increased in this channel and the fire end adjusted but the trouble still continued and spread to the other channels. At 2.00 a.m. one of these registered a temperature of 1,220 degrees. The discharge was increased in all channels but this did not remedy the trouble. At 2.25 a.m. were forced to cut off the exhauster as it would not handle the gas. A pressure was recorded at the suction inlet to the exhauster and this caused a big pressure on the retort which completely upset the feeding. The gas was bled to the atmosphere and an inspection made. A slight leak in the combustion flue was noticed. The induced draft fan at the dryer stack was cut off and the leak immediately disappeared. A much greater suction had been employed in both the combustion flue and down take than previously, which was accomplished by putting a temporary baffle in the dryer stack and employing fan. This gave the full effect of the fan toward removing the gases. This point brings out the importance of balanced pressures in order to maintain uniform operation. When the trouble started the oil had been cut off and at 4.40 a.m. the temperatures were again normal. Gas was then turned on and dryer fan speed was reduced considerable and operation was resumed with notably lower suction in both combustion flue and downtake. At 5.30 the exhauster was turned on and trouble started immediately. At times there was 15 millimeters of pressure at the suction inlet to exhauster. At 7.30 all hope of straightening out the operation was abandoned and it was decided to feed carbonized lignite, exhausting gas to atmosphere until the temperatures and feed were normal.

SEPTEMBER 26TH.

At 11.30 a.m. the feed was found to be very uniform again and at 11.45 dried coal was again fed to retort. At 3.00 p.m. the exhauster was turned on and until 6.45 operation was very erratic. Several times during this period pressure was registered at the suction inlet and the feed again became irregular. It is rather difficult to say whether the irregular operation of the retort causes this pressure at the fan or whether the pressure at the fan, which naturally puts a rather big back pressure on the retort, causes the irregularities in the feeding. I am inclined to the latter opinion in view of the apparent smoothness of operation when the gas is bled to the atmosphere. At 6.30 the temperatures started to drop and the suction at exhauster inlet increased until at 9.00 p.m. the average temperature across the bottom was 850 degrees F. and the suction registered 2.5 inches.* There seems to be considerable relation between the temperature of the retort and the suction. The temperatures were plotted on the same chart on which the suction is recorded and this relation is very marked in a large number of instances. It does not always follow however, so that some other factor as well must have a bearing on the behavior of the fan. At 10.00 p.m. the operation of the carbonizer became very uniform and for a number of hours the recording pressure gauge on the retort did not vary one millimeter. The feed was remarkably uniform and gas was burned for large part of the time, on one occasion for three hours, two burners being sufficient to maintain the tem-

*Suctions are registered close to the exhauster on the suction side.

perature. The suction recorded during this period varied between one and two inches. This seems to be the amount necessary for smooth running. It might be noted that there is no regulation on the exhauster and as previously stated there is insufficient drop in pressure ordinarily with one retort operating to put the second regulator into service. It has been suggested that a by-pass on the exhauster would help matters considerably such as was intended with the Isbell Porter compensator, but with the small flow of gas when operating one retort this hardly seems necessary. It is used however, on all constant speed exhausters and may have a bearing on the situation.

SEPTEMBER 27TH.

*Nothing worthy of note occurred until 8.00 a.m. Sept. 27th, everything running as smooth as clock-work. The temperatures were easily maintained at about 950 degrees F. and the discharge was maintained at about 12 pounds per minute. At 8.00 a.m. another period of low suction occurred and trouble ensued but this did not last long and at 8.30 operation was again smooth. At 8.35 a fire was lit in the west dryer which increased the suction in the combustion flue and downtake slightly. At noon started drying coal but still used east dryer for removing combustion gases. At 3.00 p.m. operation again became irregular as suction decreased at fan. Except for the slight trouble at 8.00 a.m. this period of twenty hours operation was ideal. As previously stated when an attempt was made to raise the temperature to 1000 or over trouble immediately ensued and no further attempts were made. From 3.00 a.m. until 8.00 p.m. operation was almost impossible owing to low suction at fan.This caused a big back pressure on the retort registering as high as 17 millimeters. Shortly after 6. p.m. a pressure of 10 millimeters was recorded at the fan and owing to the gas escaping into the room due to these high pressures working conditions became impossible. Several of the operators became sick so at 6.50 cut off fan and bled to atmosphere. Previous to this trouble the discharge had been increased and this was again reduced and fuel oil was cut off in order to allow conditions to readjust themselves. At 9.30 p.m. the temperature and feed was readjusted so started the exhauster. No suction whatever could be obtained so were forced to again resort to bleeder. During the long period of operation preceding this trouble the fan had become quite warm so no attempt was made to operate until the fan had cooled down. At 1.00 a.m. made another attempt at operating the fan and after an hour and a half of uneven operation conditions again became normal. In the meantime a second spray had been put in dust trap as considerable tar was being collected at the fan. This assisted in cleaning the gas also to cool it which seemed to help the fan considerably. Nothing further occurred during the remainder of the night worthy of note. Feeding was very uniform and pressures steady.

SEPTEMBER 28TH.

Between 12.00 noon and 1.00 p.m. Sept. 28th, it was necessary to open the bleeder for a new minutes in order to relieve the pressure on the retort but with this exception operation was very smooth throughout the day. At frequent intervals it was necessary to drain the fan and gas lines of tar. This does not speak very well for the scrubbing system. The temperature of the gas entering the fan was not allowed to get very hot and frequent temperatures were taken for this purpose. Temperatures were also taken frequently of gas at offtake.

At 1.10 p.m. the east dryer was cut off and gases were sent through the west dryer. No appreciable difference was noted in the suction at the combustion flue and downtake. From this time on until the run was discontinued the two units were operated together. Between 8.00 and 9.00 p.m. another period of low suction occurred but after an hour of irregular operation smooth running was again experienced which continued until 3.30 a.m. The suction again became very slight and irregular feeding and high pressure resulted. The suction improved later on but smooth operation did not result. This seemed to indicate some other trouble starting. It was hoped the trouble would gradually straighten itself out which it did at 8.00 a.m.

SEPTEMBER 29TH.

From 8.00 a.m. until 10.30 no trouble was experienced but at that time the suction rapidly decreased until 11.00 a.m. the gauge at the fan was registering 6 millimeters of pressure. A big back pressure was put on the retorts as a result registering as high as 16 millimeters. At 1.00 p.m. the temperature started dropping and the suction immediately increased and smooth operation resulted which continued until 6.00 p.m. when another period of low suction was experienced. This was overcome and no trouble was again experienced until 9.30 p.m. At this time the gauges on the retort were jumping up and down, first registering a large pressure and then a large suction. The recording gauge registered 5 mm. of suction and the evidence pointed to a big block in the line. Owing to the gauge at the bottom of the retort lagging behind the other two it was thought it might be in the gas clearance space in the retort or very close to the offtake in the line. The spooning hole at the offtake was opened and found to be perfectly free. The gas was then bled to the atmosphere and an attempt made to release the obstruction by working the butterfly valve. This improved matters and at 10.30 the exhauster was again turned on but smooth operation seemed impossible so the run was discontinued at 12.30 a.m. The holder at this time was full of gas which was used to calibrate the 6″ orifice referred to above. It was intended to run the retort bleeding to the atmosphere at a much higher temperature after the run had been discontinued in order to find out if any evidence of unevenness of operation could be detected but owing to the fact that the high pressure had entirely upset the feeding it was abandoned. One of the channels was not functioning at all although the discharge was normal. The thermo couple in this channel at the top was very much higher than the other two and as the adjoining channel was feeding much faster it was presumed the coal was passing unter the baffles. There are two A baffles at the top of the retort and as the middle leg of these does not rest on the slab this is possible. An inspection was made the following day and this was found to be the case. During the latter part of the run the feed seemed finer than during the first part. A screen analysis was made and this was found to be the case. The coal being used was from the storage bins where it has been for over a year and considerable slacking has resulted. The new baffles will handle this finer product without much difficulty but a coarser feed is desirable for the best results. This will be attained when operating on freshly crushed coal.

As soon as the retort had cooled down a thorough inspection was made. The short run of 8″ pipe leading from the offtake to the collecting mains was found to be practically choked solid with tar and dust. It was necessary to dismantle this and chip out the obstruction. The butterfly valve seems to increase this tendency to deposit as the greatest accumulation occurred at that point. It is proposed to eliminate

*Discharge was increased at 7 a. m. which caused the irregularity noted at 8 a. m.

these valves and replace them with gate valves which will offer less resistance to the passage of the gas. A spooning hole is to be provided in the elbows so that frequent cleaning of this section can be made during operation. The concrete retaining walls are cracked badly and are the source of big leaks whenever any suction is on the retort. I do not believe the life of these retorts will be very great, and it therefore behooves us to devote our entire attentions to overcoming the difficulties in connection with briquetting so that the product may be placed on the market, before the necessity of rebuilding the retorts arises. In any future construction a single channel for each retort should be employed and if possible drying and carbonizing carried out in a single operation. An inspection of the flues was also made and it was found that the carborundum shapes are cracking which demonstrates that this shape will not be successful. Out of 12 shapes visible from the combustion chamber 11 show cracks. I do not believe these cracks will interfere with the operation of the retorts for some time, provided the proper pressures are carried, and it is quite possible the shapes will last as long as the rest of the retort. Two more runs are yet to be made in order to complete this series. They will be made on the other two retorts and after these it will be possible to make some observations on the different types of construction.

RESULTS.

Temp. Stack.

Minimum 30°C
Maximum 39°C

(During time gases were being sent through east dryer)

Gas Offtake Temperature.

Maximum 360°C.
Minimum 264°C.

Temperature of Gas at Fan.

Maximum 50°C.
Minimum 35°C.

ANALYSES.

Samples of Carbonizer Feed.

Note. — Samples were taken half hourly over period stated below.

Date	*Time*	*Moisture Content*	
9/25–26	11 p.m. to 6 a.m.	5.0%	
9/26–27	6 a.m. to 1 a.m.	4.8%	
9/27–	1 a.m. to 12 noon	5.2%	
9/27–	12 noon to 8 p.m.	7.3%	Average moisture in dried coal fed to retorts — 5.4%
9/27–28	8 p.m. to 5 a.m.	4.5%	
9/28-	5 a.m. to 8 p.m.	3.7%	
9/28/29	8 p.m. to 4 a.m.	5.3%	
9/29	4 a.m. to 8 p.m.	7.0%	

Samples of Dryer Discharge.

Note. — Samples were taken half hourly and made into a daily composite.

Date	*Moisture.*
9/27	5.2%
9/28	5.7%
9/29	6.2%

Dryer Results.

Maximum temperature of discharge	95 degrees C.
Minimum " " "	68 " C.
Average " " "	79 " C.
" moisture content	5.7%

Screen Analysis of Dryer Discharge.

Screen No.	*%*	*Cum %*
4	.4	.4
6	1.7	2.1
8	6.8	8.9
10	12.4	21.3
14	18.7	40.0
20	17.3	57.3
28	13.8	71.1
35	12.1	83.2
48	7.0	90.2
65	4.7	94.9
100	2.8	97.7
100 (Through)	2.3	100.0

This analysis shows a slightly finer feed to carbonizers during the latter part of run D.5.

ANALYSES.

Samples of Carbonized Discharge During run "D-5".

Date	*Time*	*Temp. ½ hour previous to sample.*	*Temp. at time of sample.*	*% V.C.M.*
9/25	11.00 p.m.	810 degrees F.	840 degrees F.	18.2
9/25	12.00 p.m.	810 " "	860 " "	19.6
9/26	1.00 a.m.	830 " "	860 " "	22.4
9/26	2.00 a.m.	870 " "	890 " "	16.5
9/26	3.00 a.m.		960 " "	16.4
9/26	4.00 a.m.	840 " "	920 " "	11.9
9/26	6.00 a.m.	790 " "	730 " "	24.0
9/26	7.00 a.m.	760 " "	800 " "	23.3
9/26	7.00 p.m.	1000 " "	950 " "	14.9
9/26	12.00 Midnight	960 " "	955 " "	14.2
9/27	1.00 a.m.	950 " "	950 " "	13.9
9/27	2.00 a.m.		920 " "	15.8
9/27	3.00 a.m.	930 " "	960 " "	15.1
9/27	4.00 a.m.	945 " "	910 " "	16.5
9/27	5.00 a.m.	915 " "	890 " "	14.9
9/27	6.00 a.m.	950 " "	950 " "	14.0
9/27	7.00 a.m.	900 " "	905 " "	16.6
9/27	8.00 a.m.	890 " "	915 " "	18.1
9/27	10.00 a.m.	925 " "	930 " "	14.5
9/27	11.00 a.m.	920 " "	950 " "	12.9
9/27	Noon	950 " "	945 " "	12.3
9/27	1.00 p.m.	930 " "	940 " "	12.5
9/27	2.00 p.m.	850 " "	860 " "	15.9
9/27	3.00 p.m.	805 " "	795 " "	21.8
9/27	4.00 p.m.	835 " "	915 " "	16.8
9/27	6.00 p.m.	850 " "	875 " "	18.1
9/27	7.00 p.m.	875 " "		13.7
9/27	8.00 p.m.	1040 " "	990 " "	10.0
9/27	9.00 p.m.	960 " "	920 " "	14.2
9/27	11.00 p.m.	800 " "	825 " "	14.2
9/28	9.00 p.m.	906 " "	930 " "	16.3
9/29	1.00 a.m.	860 " "	860 " "	15.8
9/29	3.00 a.m.	875 " "	850 " "	20.2
9/29	5.00 a.m.	915 " "	930 " "	16.2

Average 16.2

Discharge.

Dried coal fed to retort — 7.55 p.m. Sept. 25th, 1922.
Run discontinued — 12.30 a.m. Sept. 30th, 1922.
Average discharge per channel — 959 grams — 2.1 lbs. per min.
Total coal carbonized 38.2 tons.

Gas Results.

Fuel consumed from 3.00 p.m. 9/26 — 2 p.m. 9/27

Minutes oil 443
Minutes gas 913
% oil 32.7
% gas 67.3

Fuel consumed from 2.00 a.m. 9/28 — 12.00 midnight 9/30.

Minutes oil 1004
Minutes gas 1773
% oil 36.4
% gas 63.6
Average percentage gas 65
" " oil 35
Average temperature 950 degrees F. approx.
Average yield gas 2.73 cu. ft./lb. residue.

Note. — No account was taken of those periods during which oil and gas was burned together, or those periods when gas was allowed to escape to atmosphere.

(*Signed*) R. A. STRONG.

BIENFAIT, SASK., *January 5th, 1923.*

RUN ON No. 3 CARBONIZER FROM DECEMBER 21ST, 1922 TO JANUARY 1ST, 1923.

"*D-6*"

This carbonizer is constructed of double slabs bonded together with the joints staggered. The floor is 2" thick and a sliding joint is provided at both sides and top to allow for expansion. The baffles used were called type F and are exactly the same as type E except in the width which is 11-½" instead of 11-⅞". The shortening of this dimension was made necessary in order to allow for an overlap of the side walls. At the bottom of the retort resting against the end plate is one row of "D" baffles. Following this is one row of "C" and then two rows of "C's" cut down to 7-½". 57 rows of "F" baffles are used which leaves 2" between the last row and the hopper plate.

The carbonizer was heated with a wood and coal fire for several days and then brought up to the desired temperature with oil. Dried lignite was put in at 3.00 p.m. December 21st. As soon as the gas was rich enough to burn the fan was turned on but it was found that during the cold weather the oil in the dash pot of the sensitizer had congealed and this had to be changed before it would function. In the meantime operation was continued using the bleeder. Operation was fairly smooth except for some small difficulty in adjusting the blades in the paddle wheels in order to get a uniform discharge. At 5.30 a.m. the middle pyrometer indicating the temperature in one of the channels was mounting rapidly while that at the bottom was dropping. This indicated that the coal was not moving although the discharge remained constant. The coal over this channel in the hopper was not moving at all and in the adjoining channel was feeding at a much faster rate than any of the others. This indicated that the coal was moving under the mid rib in the old style baffles used at the bottom of the retort. This had occurred during the other runs and could hardly be conceived to be the cause of the stoppage. Carbonized coal was introduced and the retort emptied. The burning seemed to eliminate the trouble so coal was again fed and at 1.15 p.m. December 22nd, dried coal was put in the hopper. At 3.00 p.m. the gas system was tried and continued using the fan to take off the gas until 8.00 p.m. In order to maintain the necessary suction the holder was never allowed to go above one foot in height. The gas was burned as it was made and no attempt was made to measure it in the holder. Owing to leaks we were forced to operate on a slight vacuum and analyses were made on the gas to keep the oxygen within safe limits. At 8.00 p.m. there was evidence of burning in the retort so closed down gas system and operated again on bleeder extinguishing the fire by putting a pressure on the retort. About this time the middle channel (hereafter called No. 3) again gave trouble and it was necessary to again clean out the retort. The evidence as to cause was not quite clear so it was decided to carry on again and see if the cause of the trouble could be deduced. There was a large accumulation of dust and tar in the offtake and this was removed and carbonized coal was introduced at 12.25 a.m. Dried coal was fed at 4.30 a.m. December 23rd. No trouble was experienced until 3.00 p.m. when No. 3 again stopped feeding. The safety valve and offtake covers were removed and another large accumulation of tar and dust was found to have collected in the offtake. One of the holes in the cover tiles over No. 3 channel was directly under the offtake and it was supposed that some of this material would fall through the hole and plug the channel. To eliminate this a plug was inserted in the hole and the retort started again. It must be remembreed that all this operation was carried on allowing the gas to come off thru the bleeder. The gas system had shown that it was impossible to maintain the desired suction so no further attempts were made to use it while awaiting the arrival of the turbine.

Owing to the programme adopted, which was to keep the retort going we did not want to shut down and take off the cover plates in order to determine the cause of the trouble so at 7 a.m. Dec. 24th. raw coal was again fed to the carbonizer but No. 3 again have trouble and at 10.30 a.m. were forced to clean out again. Operations were resumed at 4.45 p.m. Dec. 24th., and continued until 4.30 a.m. Dec. 25th, when the same trouble became apparent. Started up again at 7.00 p.m. Dec. 25th, after having cleaned out the retort but were forced to discontinue operations at noon on Dec. 26th. This kind of operation was impossible and it was decided to take off the bottom cover plate to see if the cause could be discovered. A few small remedies had been applied each successive time we closed down but they did not get at the cause of the trouble. Inspection showed a considerable accumulation of ash on the cover tiles which means that the gas clearance space will ultimately plug up. From our experience with No. 5 carbonizer I think this is a very serious difficulty. The old style baffles were badly warped and did not offer any resistance to the passage of the coal from No. 4 to No. 3 channel. The gas chamber was cleaned and the baffles remedied and operations were started again on Dec. 29th, at 6.20 a.m. after having brought the carbonizer up to heat with carbonized coal. At 9.30 p.m. No. 3 channel plugged again and this time decided to risk getting gassed to find out the cause of the trouble so closed the bleeder valve after the seal in the hopper was broken and allowed the gas to come into the room. In the meantime we opened up the offtake and discovered the tar was running back into the carbonizer. The level indicated an upward tilt to the bleeder pipe and this was remedied. This shows that the bleeder through the roof would never have functioned very long without causing the same trouble.

The carbonizer was again started and raw coal was fed at 8.00 a.m. on Dec. 31st. During the previous attempts the weather had been fairly mild and there was very little wind. About this time the weather suddenly became quite cold and high wind arose from the north east which incidently is the prevailing direction. The back pressure caused by this wind sent the gas through every leak and crack in the retort of which there are many. Working conditions were absolutely impossible although the men gamely stuck to their posts until they were badly gassed. Heptinstall reported that the men would not work in these conditions any longer and it seemed as though there was no remedy but to shut down. We were saved this necessity however owing to No. 3 channel plugging at 7.15 a.m. on Jan. 1st. In this instance liquid tar was running out the discharge spout and as soon as this was cleaned out the entire volume of gas poured out of this spout while none came through the bleeder. One of the men had to discontinue work through being gassed and Mr. Heptinstall required the services of a doctor. The retort was emptied however and an examination made. It was found that the icy cold wind which was blowing into the bleeder caused the tar to condense at the elbow and this had built up in the offtake until the slope allowed the liquid tar to run back into the retort. No. 3 channel being directly under the offtake had received the full benefit and the coal had coked to a solid mass in the retort.

An examination of the retort was made and five out of six visible tiles are found to be cracked. The cement is badly cracked both at the bottom and at the top and it seems impossible to stop these leaks.

In conformity with the decided programme No. 5 retort is being heated up and we will operate this for a trial run in order to determine its eccentricities and as soon as the turbine is installed the three will be put into action for as long a period as is possible.

The total time of the run was 255 hours including shutdowns. The total time running on dried coal was 81 hours. Average discharge was 750 pounds per hour or a total of 30.4 tons of coal carbonized.

The temperatures during the operation periods were maintained between 1000 and 1100 degrees F. This was considerably higher than the preceding run. The samples analyzed during the run are as follows:

Composite Samples.

Dec. 24th, 25th.	9.00 p.m. to 4.30 a.m.	10.6% V.M.
29th	3.00 p.m. to 5.00 p.m.	14.6% V.M.
29th	5.00 p.m. to 8.00 p.m.	14.6% V.M.
31st	2.00 p.m. to 8.00 p.m.	8.2% V.M.
31st Jan, 1,	8.00 p.m. to 8.00 a.m.	10.3% V.M.

These are distinctly better results than the previous run on retort No. 1.

(*Signed*) R. A. STRONG.

APPENDIX 27

Report on Operations During 1923.

By R. A. STRONG.

This report is divided into two sections: —

(*A*) *Report of Hood-Odell oven operations at Grand Forks, N.D., during experimental run in February, 1923.*

(*B*) *Report of Hood-Odell oven operations at Lignite Utilization Board plant, Bienfait, July-December, 1923.*

(A) In view of the decision to abandon further work on the retorts installed at Bienfait, it was decided to investigate a retort which had been evolved under a co-operative agreement between the United States Bureau of Mines and the University of North Dakota. This retort, of the shaft carbonizer type, was referred to as the Hood-Odell oven, and carbonization was effected by burning a portion of the fuel. The burning of the gases in direct contact with the lignite gave sufficient heat to carbonize the mass of lignite with a very small loss in fixed carbon. The excess gas was not recovered but was burned at the top of the oven. A diagram of this retort is shown in Fig. No. 53.

A small retort of this nature was built at Bienfait in order to test out the principle, and the results were sufficiently promising to warrant a recommendation that 100 tons of Souris lignite be carbonized in the retort built at Grand Forks, N.D. This recommendation was accepted, and accordingly in February 1923, a shipment of this amount went forward, and a test was made.

The oven erected at Grand Forks had not been provided with any shelter. It was built for experimental work only, and it had not been intended to operate it during the extreme winter temperatures. The weather prevailing during the attempted experiment was very severe, and it therefore became extremely difficult to maintain the heat necessary for proper carbonization, which in turn markedly reduced the capacity of the retort. Several runs were made, however, and observations taken on: —

1. Character of char.
2. Analysis of char.
3. Effects of different screen sizes.
4. Clinkering, etc.

The results obtained are shown below.

RUN NO. 1

Coal used — Nut slack, Bienfait Mine.

ANALYSIS.

	As received	*Moisture free*
Moisture	33.5%	0.0%
Vol. Matter	26.6%	40.0%
Ash	8.5%	12.8%
Fixed Carbon	31.4%	47.2%
B.T.U./lb.	6974	10476

Screen Size.

Inches	%
2 — 1½	19.3
1½ — 1¼	27.7
1½ — 1	10.7
1 — ¾	12.8
¾ — ½	12.8
½ — ¼	10.1
¼ — 1/8	3.6
1/8 — 0	3.0

	Analysis of Char	*Moisture Free*
Moisture	7.6%	
Vol. Matter	19.4%	20.8%
Ash	16.1%	17.5%
Fixed Carbon	56.9%	61.7%
B.T.U. per lb	9892	10690

Analysis of Screen Sizes.

	On ¼″		*On ½″*	
Moisture	10.9%	....	14.8%	....
Vol. Matter	25.5	28.7%	29.5	34.5%
Ash	18.7	21.0	16.2	19.1
Fixed Carbon	44.9	50.3	39.5	46.4

	On 1/8″		*Thru 1/8″*	
Moisture	8.3%	....	6.2%	....
Vol. Matter	22.0	24.1%	17.2	18.4%
Ash	16.7	18.2	17.1	18.2
Fixed Carbon	53.0	57.7	59.5	63.4

The yield on the basis of the ash content is 48.5% (moisture free char). The fixed carbon in the char on this basis should be 64.8%. The actual fixed carbon is 61.7% — a difference of 3.1% of the char, or 1.5% of lignite used.

RUN NO. 2.

Coal used — Same as in Run No. 1.
Screen Analysis — Same as in Run No. 1.

Analysis of Char.

Moisture	14.4%	....
Vol. Matter	22.1%	25.8%
Ash	15.6%	18.2%
Fixed Carbon	47.9%	56.0%
B.T.U. per lb.	8820	10300

The yield on the ash basis (moisture free char) is 46.7%. The fixed carbon in the char on this basis should be 67.4%. The actual fixed carbon is 56% or a difference of 11.4% of the char, —5.3% of the lignite used.

Screen Analysis of the Char.

Inches	%
¾ — ½	11.8%
½ — ¼	16.3%
¼ — 1/8	24.8%
1/8 — 0	47.1%

RUN NO. 3

Coal used — Western Dominion Collieries — Screenings.
The coal was much finer than in the previous runs.

Screen Analysis.

Inches	%
1½ — 1¼	8.8%
1¼ — 1	10.7%
1 — ¾	2.7%
¾ — ½	37.3%
½ — ¼	26.1%
¼ — 1/8	8.8%
1/8 — 0	5.6%

Analysis of Coal.

	As received	*Moisture free*
Moisture	32.8%	....
Vol. Matter	27.1%	40.3%
Ash	6.9%	10.3%
Fixed Carbon	33.2%	49.4%
B.T.U. per lb.	7329	10915.

Analysis of Char

Moisture	7.4%	....
Vol. Matter	18.5%	20.0%
Ash	14.7%	15.8%
Fixed Carbon	59.4%	64.2%
B.T.U. per lb	10156	10980

Yield on ash basis (moisture free char) 43.7%.

The fixed carbon in the char, on this basis, should be 76.0%. The actual fixed carbon was found to be 64.2% — a difference of 11.8% of the char, or 5.2% of the lignite used.

Screen Analysis of Char.

Inches	%
¾ — ½	4.4%
½ — ¼	11.9%
¼ — 1/8	33.7%
1/8 — 0	50.0%

RUN NO. 4

Coal used — Same as in previous run.
Screen analysis — Same as in previous run.

Analysis of Char.

Moisture	8.6%	....
Vol. Matter	21.1%	23.1%
Ash	14.6%	15.9%
Fixed Carbon	55.7%	61.0%
B.T.U. per lb.	10042	11000

Yield on basis of ash (moisture free char) 43.4%.
The fixed carbon on this basis should be 76.5%.

The actual fixed carbon was found to be 61.0% — a difference of 15.5% of the char or 6.7% of the lignite used.

The average results of the four tests show that the fuel used in processing, expressed in percentage by weight of the total lignite charged, is 4.9%. This is, of course, in addition to the gas evolved most of which was wasted. Since this figure represents combustible material it is probably safe to say that the fuel consumption on a basis of heating value is (4.9 x 2) — 9.8%*. (Carbon has practically twice the heating value of lignite).

No further tests were made. Sixty tons of coal had been carbonized, and considerable information secured. An average of the results obtained showed 21.4% of volatile matter left in the char. This was far too much but considering the conditions under which the test was made it was very favourable. The loss in fixed carbon amounted to 10.4%, and it was estimated that this could be materially reduced by some changes in the design.

Clinkering caused very little trouble using the two scale mentioned above. It was found necessary to clean the air ports by poking about once an hour but the clinker formed did not adhere to the walls of the retort or cause plugging within.

Screen size of coal is an important factor and has a direct bearing on the capacity of the retort. If the coal is not crushed fine enough, the large pieces will not break up and become carbonized in their passage through the retort, while a high percentage of very fine sizes tends to increase the loss of fixed carbon. The top size should not exceed 1½", and ¼ inch is a good size for the lower limit. The dust should be kept at a minimum.

The char is grey in colour, has a metallic ring, and is quite hard.

The conclusions arrived at from the experiment were that the retort was sound in principle, cheap to construct and easy to operate. It was recommended to the Winnipeg meeting of March 3rd, that one should be built at Bienfait incorporating several changes in design which were felt to be necessary.

(B) Operations at Bienfait, July to Dec. 1923.

The retort as built at the Bienfait plant is shown in section in Figure 54. In this installation provision was made for recovering the gas. This was accomplished by inserting a slotted pipe with a metal curtain in the coal mass, directly above the upper combustion zone. The offtake was connected to the gas system as installed for the former retorts, and the line was continued to the power house where the gas was burned under the boilers. Water seals were provided at the offtake and at the burner.

The air for combustion was provided by means of a Buffalo Volume Blower which was connected to the four cast iron air ducts in the combustion zones. These were perforated allowing even distribution of the air throughout the length of the retort. The air was delivered at a pressure of ½ inch of water.

The side baffles were made of cast iron suspended on the cast iron air ducts. The central baffles were made by placing three cast iron pipes in the position shown. A few minor changes were also made in the discharge in order to seal more effectively the bottom of the retort, and provide a more uniform discharge of the char.

The retort was built in the open, and was connected to the existing system of crushing and handling It was necessary to change the crusher however, and a Jeffrey Single Roll Crusher was installed. This machine worked very satisfactorily and gave a fairly uniform screen product. A view of this retort as erected is shown in plates Nos. 11, 12 and 13.

The oven has been operated continuously for six months with only a few interruptions mainly for purpose of making slight alterations. Operating results are shown below.

Total coal charged	3,000 tons	approximate figures.
Total char recovered	1,300 tons	

Analysis of coal as charged

Moisture	33.3%
Vol. Matter	27.6%
Ash	6.4%
Fixed Carbon	32.7%
B. T. U. per lb	7,390

Analysis of Char

Moisture	Nil
Vol. Matter	12.2%
Ash	15.1%
Fixed Carbon	72.7%
B. T. U. per lb	11,800

Screen Analysis of Lignite

On 2"	......
" 1½	30.5%
" 1¼	17.3%
" 1	7.0%
" ¾	10.5%
" ½	13.6%
" ¼	9.0%
" 1/8	6.0%
Thru 1/8	6.1%

Screen Analysis of Char.

On ¾"	1.9%
" ½	6.4%
" ¼	22.5%
" 1/8	28.8%
Thru 1/8	40.4%

*This figure was materially reduced with the improved setting erected at Bienfait.

The above figures are the average of results obtained during a ten day test. The average yield of char is 42.3% based on the ash content. The fixed carbon in the char on this basis should be 77.6%. The actual fixed carbon in the char is 72.7% — a difference of 4.9% of the char, or 2.1% of the lignite used.*

Assuming this to be combustible, and that its heating value is twice that of lignite, the fuel consumption on a basis of heating value is 2.1 x 2 = 4.2%. This is a marked reduction over the results obtained in February.

The gas recovered is of low heating value being mostly producer gas. The quantity recoverable is 16,000 cu. ft. per ton of lignite charged, and its average heating value is about 110 B. T. U. It is estimated that, in a commercial installation, there would be sufficient gas available to supply the power requirements of the entire plant, crushing, carbonizing and briquetting, and in addition a large surplus would be available during the night time when the load is light. This can be utilized for operating a still for the distillation of tar or other purposes as desired.

An average analysis of the gas is shown below.

CO_2	10.2%
Ill	.4%
O_2	1.0%
CO	13.7%
H_2	11.5%
CH_4	2.4%
N_2	60.8%

This method of carbonization materially reduces the by-product yields, but as these are of uncertain value it is not a material objection. Tests were made to determine the quantity of tar recoverable, and the average of a large number of determinations was 2½ to 3½ imperial gallons per ton of lignite charged.

Distillation of the tar yielded the following results:

0-200 degrees C	7.0%
200-210 degrees C	2.7%
210-235 degrees C	8.8%
235-270 degrees C	12.2%
Pitch	66.3%
Loss	3.0%
Melting point of pitch	140°F. (Cube method)
Free carbon in tar	1.4%
Density of tar	60/60°F. 1.0503

The oils should be valued only as a liquid fuel, but the pitch can be utilized as a binder for the briquettes. Tests on the pitch show that it mixes with ordinary coal tar pitch, and hence is value is equal to that of the latter material delivered at the plant. The amount recoverable in a 100 ton plant is equivalent to about 25% of the binder requirements. Briquettes have been made using lignite pitch in the above proportions. This will be discussed in appendix 30.

Tests on the oil yieded the following results:

Gravity	0.980 @ 60°F.
Flash Point	132° F. (P. M. Closed test)
Fire Point	223° F. (P. M. open cup)
Freezing Point	5° F.
Viscosity	14 sec. {Admiralty Redwood at 32° F.}
Sulphur	0.6%
B. T. U. per lb	16,500

The recovery of the tar offers some so far unsolved problems. It forms a most persistent emulsion containing as much as 65% water, and does not respond to the ordinary methods for reducing the water content.

OPERATION RESULTS

During the operation of the retort observations were made on:—

1. Uniformity of discharge.
2. Life of structure.
3. Life of Cast Iron Baffles.
4. Possibility of housing retorts.
5. Clinker troubles.
6. Screen analysis of coal.
7. Efficiency of the apparatus.
8. Costs.
9. Capacity.
10. Possibility of operating for a higher yield.
11. Possibility of using char direct as fuel.

UNIFORMITY OF DISCHARGE

It was found that with a little experience the operators could easily maintain the char at the desired volatile content. During the first part of operations char ranging from 9 to 19% of volatile was obtained, but after more experience was gained it was found quite easy to operate between the desired limits of 10 to 15%.

LIFE OF THE RETORT

Standard firebrick is used throughout the structure, except for Sil-o-cel insulation, and as the operating conditions are not severe it should have a reasonable life. No definite statement can be made in this connection as the time of operation does not warrant. After six months, however, the interior lining of the retort showed little or no deterioration.

*Compare these figures with those obtained during test made in Grand Forks installation.

LIFE OF CAST IRON BAFFLES

The side baffles are subjected to rather severe treatment and some of these were burned out in a very few days. More careful regulation resulted in a much longer life, however, and the use of a small jet of steam immediately below the baffles has increased the life to approximately three months. The cost of renewal is small and could not be considered excessive. The use of heat resisting alloys might decrease the cost of renewals but this could only be determined by experiments over an extended period of time.* The central baffles and air ducts show practically no signs of deterioration after six months of operation, and a reasonably long life can be expected from them. The gas offtake and metal curtain will last indefinitely as the temperature at this point is below 200 degrees Fahrenheit. A slight change in design will make the removal and renewal of all baffles a very simple operation.

POSSIBILITY OF HOUSING RETORTS.

The retort was built outside in view of the uncertainty of gas leakage. It was found that after a few minor changes this trouble could be entirely overcome by operating under a sufficient vacuum. It is necessary to operate at a slightly higher vacuum than the pressure at which the air is delivered and the prevailing suction was ¾ to 1″ at the offtake. The retort is started up by filling it to the lower combustion zone, and then starting a fire with wood. Raw lignite is thrown on and air supplied, the fire being gradually built up until the offtake is sealed when the fan for removing the gas is turned on. Previous to this a large quantity of gas necessarily escapes but at all other times it is quite free from this nuisance. If a vent system is provided for these occasions no difficulty would be encountered from placing the retorts within a building.

CLINKER TROUBLES

If a coal with a low ash is used very little trouble results from clinkers. Those that are formed do not adhere to the metal baffles but form on the walls immediately above and can easily be disloged with a poker bar without disrupting the operation.

SCREEN ANALYSIS OF COAL

It is rather difficult to maintain a constant screen analysis in view of the large amount of breakage before the coal is charged in the retort. Considerable trouble was expected from fines, but it was found that the retort was very flexible in this respect, and while the best results were obtained when the coal conformed to the sizes given above, no great difficulties were encountered when using coal with a high percentage of dust.

EFFICIENCY OF THE APPARATUS.

Tests were made to determine the efficiency and the results are shown in the following table.

Heat Balance

Sensible Heat in gas	32,039	B. T. U.	
" " " water	96,444	"	
" " " char	188,700	"	
" " " tar	1,357	"	
	318,540		2.16%
Latent Heat in gas	1,793,000	B. T. U.	
" " " char	10,030,000	"	
" " " tar	595,000	"	
	12,418,000		84.02%
Heat lost	2,043,460		13.82%
Heat in one ton of coal @ 7,390 BTU per lb.	14,780,000		100.00%

Recovered.

Gas	1,793,000	12.13%
Char	10,030,000	67.86%
Tar	595,000	4.03%
		84.02%

COSTS

The oven erected at Bienfait cost $3,874.24 including accessories. This figure could be materially reduced when building a number, and it is estimated that in a battery formation the setting would cost approximately $3,000.00 per retort. The cost of repairs is estimated to be within a reasonable figure, and the labour cost is decidedly low. Three men per shift would be the labour requirement for the operation of a battery of 10 ovens.

CAPACITY

The capacity of the oven is dependent on several factors. Capacities ranging as high as 14 tons of char per 24 hours have been attained, but when operating under these conditions it is practically impossible to keep the top of the oven free from gas leakage. The capacity is reduced when excessive fines are encountered, as it is difficult to get the air blast through the bed of finely divided coal. Large coal also decreases the capacity as the rate of travel has to be slowed down in order to effect the proper degree of carbonization.

*Two baffles of Hybnickel and two of Fahrite were tried out and no signs of deterioration could be detected after 20 days operation.

The oven can be operated under varying conditions of feed and kept free from gas leakage, at an average of 10 to 12 tons of char per 24 hours. Taking an average of 11 tons per day with a yield of 42.5% the lignite treated will be equivalent to 25.9 tons per day. Assuming an oven cost of $3,000.00, the capital cost per ton of coal charged is $116.00, a very reasonable figure.

Possibility of Operating for a Higher Yield

It was suggested that the cost of operation might be materially reduced by operating at a higher capacity producing a char that would contain approximately 25% of volatile matter. This experiment was tried and it was found rather difficult to maintain a fire in the upper combustion zones. This makes the operation a much more difficult one and requires the constant attention of the operators. In addition to this the gas is so weak as to be of no value which is a big loss. If the retorts were to be housed this gas would have to be removed which would be adding an expense for a valueless product. The theoretical yield, not allowing for loss of fixed carbon due to combustion, would be 48.8% or a difference of 6.3%. This would not make up for the loss of gas for power which is the equivalent of 24 tons of coal per day in a battery of 10 ovens with 80% operation. It is also likely that the briquettes from this product would not be held in the same favour as those of a lower volatile content.

Possibilities of Using Char Direct as a Fuel

In the belief that a market might exist for the char as recovered from the oven, tests were made on various types of stokers designed for handling a finely divided fuel. A carload was forwarded to the Government Power House at Regina and burned in the Laclede Christy chain grate stokers installed there. The fuel was very unsatisfactory when used alone, and a large percentage was lost through the grate openings; but a mixture of 50% of this fuel with Alberta steam coal gave excellent results and was much superior to the Alberta coal alone.

Another car was forwarded to the Municipal power house at Regina to be tried on a Riley stoker. This test was more satisfactory than the former but the percentage of loss through the grate openings was high. The engineer in charge believed it could be used to advantage but from the report received of the test it would appear that in this case also, mixing would be necessary.

Another test was made at the Swift-Canadian plant in Winnipeg under hand fired conditions with herring-bone grates suitable for a finely divided fuel. As the results from this test were also unsatisfactory no further shipments were made.

The char was also tried as a gas producer fuel and tests were conducted at Souris, Melville and Gull Lake.

The Souris installation consists of a Mond type of producer and the fuel used has been nut size lignite. It was found that considerably less char was necessary but the saving did not offset the increased cost of the char. Considerable operating difficulty was caused by the fineness of the char, but as this plant does not operate with an exhauster, the suction being provided by the engine, it is possible that better results might be obtained if an exhauster were used.

The reports obtained from Melville and Gull Lake were to the same effect.

The conclusions from the above tests are that the possibility of using char as a fuel for either gas producer or power house work is at present negligible owing to:—

1. Its cost compared to raw lignite.
2. Its screen size.

No tests were made using char in pulverized fuel installations but it would seem that this fuel could be economically used under those conditions.

During this year's operations the other departments of the plant were operated more continuously than during the previous year and an opportunity was had of observing their weaknesses. Three main difficulties presented themselves which have a distinct bearing on the location and operation of a commercial plant. These are namely, water supply, switching, and sewage disposal.

Water Supply

The plant is located one and a half miles from the river and a pipe line, owned and operated by an adjoining mine is used for supplying water to the plant. The line is in a state of poor repair and the supply is constantly jeopardized. At no time during the year was the quantity used equal to the requirements of a commercial plant of 100 tons per day, yet operations were constantly in danger of being suspended from the uncertainty of the supply.

Switching

The plant depends on a neighbouring mine for its switching and an agreement has been entered into between the respective parties for this service. It has been found that this is not an entirely satisfactory arrangement in view of the necessity of a definite time schedule for the delivery of raw material and removal of finished product in order not to disrupt operation.

The mining company could not supply such service without interfering with their own activities and it would therefore seem that the best arrangement for this plant would be to secure a locomotive of their own and either obtain running rights over the existing spurs or have its own outlet.

Sewage Disposal

As stated previously the disposal of sewage and water constitutes a considerable problem to a plant located between two operating mines. This department continued to be a source of annoyance throughout the year and the question of flooding neighbouring lands is a serious one. It is of prime importance that an outlet be provided for drainage in all plants of this nature.

Acknowledgment

Grateful acknowledgment is made to Messrs. O. P. Hood and W. W. Odell of the United States Bureau of Mines also to Dean E. J. Babcock and Mr. R. L. Sutherland of the University of North Dakota for their hearty co-operation in the work during the year.

APPENDIX No. 28

Report on Inspection of Nukol Briquetting Plant.

Toronto, Ontario *November 1st., 1920.*

by

R. A. STRONG and H. JOHNSON.

INTRODUCTION.

The inspection was conducted under arrangements made with Mr. F. H. Slater, of the Nukol Briquetting Co., Toronto, with the consent of Mr. McGraw of the General Briquetting Co., New York, engineers for the Nukol Company.

The writers received instructions from the Lignite Utilization Board to examine and report upon, the layout, equipment and operation of the above briquetting plant; to conduct tests to gain all possible information of value to the Board for the erection and operation of their plant near Bienfait, Saskatchewan; and to conduct any other tests desired by Mr. Slater for the information of his company. No tests were to be conducted, however, which would interrupt the operation of the plant.

In accordance with the above instructions the writers reported to Mr. Slater in Toronto on April 19th, 1920, and spent seven working days investigating his plant.

The following report enumerates the specific points on which information was desired; it gives a general description of the plant as a whole, and a more detailed description of the principal machines; it also includes an account of the tests conducted and the information gained thereby.

OBJECTS AND RESULTS OF INVESTIGATION

(1) To obtain the general layout of the machinery and to trace the movement through the plant of raw materials and finished product. This was done.

(2) To study the method of receiving, storing and handling the raw coal. This was done.

(3) To study the method of receiving, storing, heating and circulating the binder employed. This was done.

(4) To study the construction and operation of the coal dryers to determine the fuel consumption and the water removed. No data as to the thermal efficiency of the dryers was obtained.

(5) To study the method of regulating and proportioning the dried coal and binder fed to the mixing system. This was done.

(6) To study the construction, operation and efficiency of the different mixers employed. It was found to be impossible to gain exact information as to the efficiency of any mixer without modification and consequent interruption of the plant.

(7) To determine the crushing undergone by the coal in its passage through the masticator. This was done.

(8) To study the construction and operation of the briquetting press and to especially note the effect of the physical condition of the charge on the quality of the output. This was attempted and some information gained.

(9) To study the effect of water cooling on the briquettes. This was done.

(10) To study the time taken by the coal and binder to pass through each machine and their temperature when entering and leaving the principal machines. This was done.

(11) To determine the power requirements of the different operations. The total horse power was ascertained but not its distribution.

(12) To determine the steam consumption of the plant. No information was gained on this point.

(13) To sample and analyse the raw materials and finished product. This was done.

(14) To ascertain the staff and labour required to operate the plant. This was done.

DESCRIPTION OF THE PLANT.

The plant is situated at the foot of Cherry Street on Ashbridge Bay, a new industrial district of Toronto and has water and rail transportation facilities.

The coal briquetted is anthracite culm dredged from rivers and creeks in the Pennsylvania anthracite district. The binder employed is asphalt obtained from the Montreal refinery of the Imperial Oil Co.

The 7 oz. egg shaped briquette made is either delivered by truck direct from the plant to the consumer in Toronto, or shipped by rail to outside parts. The briquettes are bagged for the local trade.

The buildings are old, of frame and corrugated iron construction and have been adapted to their present use from previous occupation. The plant comprises a coal storage yard; a small boiler house; the briquetting building, with storage bins and loading facilities; also workshops, wash room, stores, work office, and weigh scales. The main office of the company is situated in the Exchange building in the business district of the city.

Figure 64 is a flow sheet of the materials through the plant, shown in diagrammatic elevation.

The rated capacity of the plant is 100 tons of finished briquettes per 8 hour day.

Coal Handling and Storage.

The raw coal whether brought in by water or rail is stored in the yard by means of a crane with a clam shell bucket. From this pile the coal is elevated by the same crane to a bin whose capacity is 40 tons. This loading system will only allow 35 tons to be placed in the bin and it is necessary to operate the crane for a longer period than the plant in order to keep a constant supply. This method is to be replaced by a fixed bucket elevator supplied by a portable belt conveyor.

The bin discharges over the centre of the two dryer feeds, and the coal is delivered to two inclined chutes, by a short belt conveyor running under the bin. These chutes instead of being straight have a 90° bend at which points it is necessary to keep men for the purpose of keeping the coal moving. The coal being wet will not follow this system of feed and is inclined to clog. A third man is kept at the junction of the chutes to remove pieces of wood etc. which get into the bin by the crane method of loading. This fault is to be remedied by a vertical drop from the bin and the installation of a screw conveyor leading to each dryer.

Dryers.

There are two rotary type dryers, each 40 feet long by 4 feet inside diameter with a pitch of ½ inch to 1 foot. They are made of one half inch plate, five sections in length, each section being a single plate lapped with two rows of rivets. There are six "Z" bars in the circumference running the length of the dryers. They are operated at a speed of 10½ R. P. M. The capacity of each dryer was found to be about 15 tons of dried coal per hour. The dryers were purchased second hand from a cement plant in Sudbury. The tires are at present a source of dissatisfaction. They are attached to the dryer by means of grip blocks which are out of alignment.

The furnace which is located at the lower end is supplied with draught by a perforated 1" steam pipe ring, 6 inches in diameter, beneath the grate. Six tons of coal are consumed in these furnaces per eight hours. The fuel used is the dried oversize from the screen.

The fan used is a suction type, 4 feet in diameter and 16 inches wide with a speed of 620 R. P. M. driven by a motor at 1440 R. P. M. A 24 inch pipe connection leads from the dryers to the fan. A similar sized pipe connects the fan with a 40 foot stack. The pressure taken with a gauge was 1.4 inches.

The coal is taken from the dryers by means of a horizontal screw conveyor to a bucket elevator which delivers it to a screen.

Screen.

The screen is a trommel type with ½ inch square mesh, 8 feet long and 36 inches in diameter with a pitch of ¼ inch per foot, driven at a speed of 27 R. P. M.

The oversize from the screen is delivered to the furnaces of the dryers by means of a chute; the undersize going by the same method to a bucket elevator which delivers it to two conical feeders.

Feeders.

The feeders regulate the flow of coal through the plant. They consist of two conical bins with a revolving plate at the base travelling at 11½ R. P. M. The coal passes on to the plate through vertical gates which are adjustable. The average height of these gates is 15 inches. A fixed scraper above each plate set at an angle of 20° to the line joining the centres of the two feeders, discharges the coal into a helical mixer.

Regulation of Binder Flow.

The binder is delivered through a 1 inch pipe directly into the coal as it is fed into the helical mixer. A man is stationed at the feed end of the mixer to watch the supply of binder. At present there is no mechanical method of regulation, although they contemplate the use of a needle valve. The operator judges the supply necessary by experience only. A binder chart is used to determine the average percentage of binder in the product. The amount used is measured each day in the tanks and the percentage determined by the total output. One inch depth in the tank is 163.8 gallons or 0.73 tons, as one gallon weighs 8.87 pounds. The average consumption per day is 7 inches in the tank. This is equal to about 5 percent on a hundred tons per day basis.

Helical Mixer.

This mixer is 10 feet long and 20 inches in diameter with a removable cover. The binder is added to the coal as it passes through this mixer at a distance of 2½ feet from the feed end. The discharge is through an 8 inch opening directly into a vertical fluxer.

Fluxer.

The fluxer is of the vertical paddle type 7 feet high and 3½ feet in diameter. It is supported on four circular posts 10 feet above the floor, and is placed directly beneath the discharge from the mixer. It is operated at a speed of 25 R. P. M. Both water and steam pipes are connected to the fluxer and the regulation of each is gauged by a man at the discharge, who judges the quality of the mixture by means of its stickiness. If the mixture does not contain the correct amount of binder the operator signals to the man at the mixer to increase or decrease the binder flow. The depth of material is gauged by means of small holes in the side of the fluxer and the discharge gate regulated accordingly. Common practice is to keep it half filled. The discharge from the fluxer is carried by means of a small belt conveyor, necessitated by means of an error in erection, to the edge runner.

Edge Runner.

The edge runner consists of two solid metal wheels, 5 feet in diameter and 34 inches wide on opposite ends of a horizontal shaft which revolves about its centre in a horizontal plane. A steel plate forms the base. Their practice is to keep 1 inch of material in the machine. This is ground and mixed between the plate and the wheels. Two scrapers directly in front of each wheel on a shaft at right angles to the wheel shaft, serve to agitate the material and discharge it from the machine. The scrapers are set at about 15° to the line of travel, the outside one being ½ inch, and the inside one ¼ inch, above the bottom plate. They require constant adjusting as considerable wear takes place. The machine is 11 feet in diameter and has a casing 2 feet high surrounding it. Its total weight is 40 tons. The machine is driven from below by a large gear wheel, at a speed of 18 R. P. M. Considerable trouble has been experienced and frequent shut downs necessary, owing to the teeth in this gear wheel breaking. The discharge is in the centre and is taken by means of a screw conveyor to a bucket elevator which delivers the material to the agitator.

Agitator.

The agitator is situated directly above the press and contains two agitating paddles revolving on their own axes and four arms revolving around the axis of the agitator at a speed of 48 R. P. M. A steam con-

nection allows live steam to be injected into the mixture as required through holes in a ring. The objection to this method of adding steam is that the holes in the ring frequently clog. The agitator is 4 feet in diameter and 16 inches high. There are guides on the openings to the rolls which are not adjustable to allow for the wearing that takes place. They are now ½″ above the rolls causing considerable loss of fines. There are two gates 8 by 12 inches to allow the material to be fed to either pair of rolls in the press.

Press.

The press is of the Belgian type, with two pairs of rolls, separated by the driving gear. The rolls are 33 inches in diameter on a 12 inch shaft. There are 160 pockets in each wheel which make 7 oz. egg shaped briquettes. Alternate feed is employed. The rolls are operated at a speed of 8 R. P. M. and have a capacity of 20 tons per hour. The briquettes are taken from the press by means of a 30° steel chute to a bucket elevator which carries them to a screen.

Screen.

The screen is the squirrel cage type 8 feet long and 36 inches in diameter with a pitch of 1 inch to 1 foot. The bars are 1 inch apart. It is operated at 16 R. P. M. The fines are returned by means of a chute to the edge runner. A large amount of breakage is caused by this screen as well as by its discharge. The briquettes drop from the revolving screen on to a bar screen which is inclined at 30°. This screen is 6 feet long and 20 inches wide and made of ½ inch bars 1 inch apart. It discharges to a 30° metal chute which carries the briquettes to the cooling trough.

Cooling Trough.

The cooling trough is of concrete, 33 feet long 20 inches wide and 2½ feet deep. It is equipped with a continuous flow of water. A scraper belt travelling at 30 feet per minute, scrapes the briquettes along the bottom of the trough, which slopes upward at the discharge end. The discharge is to a bucket elevator which carries the briquettes to a storage bin.

Briquette Storage Bin.

The briquette bin is 40 feet long and 24 feet wide. It is 5 feet deep at the high side and 10 feet deep at the discharge side. It is filled by a bucket elevator at one end. There is a discharge by a vertical chute to the bagging shed, and four chutes to the cars. Owing to the lack of a belt conveyor over the bin which will distribute the briquettes in the bin, two men are required to shovel the briquettes to the different discharge chutes. This error is to be eliminated.

Binder System.

The binder is delivered in tank cars which contain steam coils. They are placed in a heated shed and steam applied. The binder when fluid is pumped by a McKinnon Rotary plunger pump travelling at 200 R. P. M., whose capacity is 1000 gallons per hour, through a three-way valve, which allows delivery either to a small tank placed above the mixer or to one of the two large storage tanks. The overflow from the small tank is returned, and by means of a three-way valve can be delivered to either of the storage tanks. By means of a valve in the system, the small tank can be cut off from the supply and the binder pumped direct to one of the storage tanks. The only means of filling the other storage tank is from the overflow from the small tank. The binder may be drawn from either of the large tanks and delivered to the small one, the overflow being returned to either tank desired.

The two storage tanks are 18¼ feet in diameter 12 feet high and are made of 1-8 inch galvanized plate. The plates are 2 feet wide and 7 feet long laid horizontally with bracing angles at each joint. The bracing angles are 1 x 1¼ x 3/16 inches and are packed with asbestos. The tanks were made by the American Sheet and Tin Plate Co., Pittsburg. Square nuts and bolts should be used instead of the screwbolts at present employed, to facilitate the tightening of the joints. The small tank is made of steel and is 2¼ feet long and 2¼ feet in diameter. It is located 4 feet above the helical mixer. The discharge is from a 1 inch pipe steam jacketted in a 2 inch pipe and the flow is regulated by means of a stop-cock.

Circulation of Steam in Binder System.

Seven lengths of 1¼ inch pipe are placed on one side of the tank car shed with connections for the coils in the tank cars. The coils in the storage tanks are 12 inches from the bottom of the tank. There are two separate feeds of 2 inch steam pipes having a common discharge. The coils are return bends, covering the full cross-sectional area of the tank. The binder suction is a 2 inch tap in the side of the tanks 5 inches below the steam coils. Considerable trouble is occasioned by having the coils at such a distance from the bottom, as the material below is not always fluid enough. The binder pipe from the pump and from the storage tanks as well as the overflow pipe from the small tank, are 2 inch pipes packed in insulation with 2¾ inch steam lines. These steam lines circulate twice in the small tank and return to the fluxer. All valves are also steam jacketted.

The binder tank car shed is 45 feet long, 16 feet wide and 16 feet high made of clap board and tar paper.

Elevators, Conveyors, Chutes, Etc.

A track crane and clam shell bucket delivers the raw coal from pile to bin.

A Belt conveyor under raw coal bin. Linear velocity 24 feet per minute. Length 5 feet, width 16 inches.

Screw conveyor at discharge of dryers, 12 inches diameter, 21 feet long, capacity 23 tons per hour.

Bucket elevator No. 1, from screw conveyor to screen. Vertical, 35 feet high, buckets 6 by 12 inches, 2 feet apart on a single chain, Jeffrey Manufacture, in metal housing.

A wooden, metal lined chute, at 45° incline, carries oversize to drier furnace. A similar chute carries the undersize to elevator No. 2.

Elevator No. 2, 25 feet high, vertical, 6 by 12 inches buckets on a single chain, Jeffrey Manufacture, elevates screened coal to a chute over the feeders. Chute to feeders is inclined at 45°.

A belt conveyor 11 feet long, 12 inches wide, travelling at 260 feet per minute on a 20° incline, carries the material from the fluxer to the edge runner.

A screw conveyor 20 inches in diam. 10 feet long, conveys the material from the edge runner to elevator No. 3.

Elevator No. 3, 25 feet high, vertical, similar to Nos. 1 and 2, discharges by means of a 50° chute, 15 inches wide, to the agitator on the press.

Bucket elevator No. 4 elevates briquettes from the press to the screen. It is 25 feet, vertical, with wooden casing. The buckets are 12 by 6 inches, 18 inches apart on a double chain with 9 inch links, discharging briquettes into a 30° chute, 6 feet long, 12 inches wide, to the screen. The fines from the screen are conveyed by a vertical chute to the edge runner.

The briquettes are conveyed from the screen to the water trough by three chutes 15 inches wide, at a 30° slope. These chutes are placed at 90° to each other and have a total length of 20 feet.

Elevator No. 5 is 40 feet, vertical, in wooden housing, open to weather with 14 by 6 inch buckets 2 feet apart. It travels at 200 feet per minute and carries the briquettes from the cooling trough to the briquette storage bin. Elevators Nos. 4 and 5, are second hand, purchased from the Cement Plant at Sudbury.

Power.

The power is supplied by five motors, on the hydro-electric system.

1. 100 H. P. Westinghouse moter, 720 R. P. M. 550 volts, 94 amps per phase, 3 phase, 25 cycle. This motor drives direct to a line shaft giving it a speed of 200 R. P. M. It furnishes power for both dryers, screw conveyor at dryer discharge, bucket elevator No. 1, screen, bucket elevator No. 2, feeders, mixers, fluxer, belt conveyor from fluxer to edge runner, screw conveyor from edge runner.
2. 116 B. H. P. Lancashire motor 550 volts, 720 R. P. M. 3 phase, 110 amps per phase. This motor drives direct a second line shaft, giving it a speed of 200 R. P. M. This furnishes power for the edge runner, elevator No. 3, briquette screen, cooling trough drag belt, elevator No. 4 agitator, elevator No. 5.
3. Wagner A. C. Motor, 10 H. P. 3 phase, 25 cycle, 1420 R. P. M., 550 volts, 10.2 amps. Drives direct to dryer fan only.
4. 75 H. P. Crocker-Wheeler motor, 550 volts, 750 R. P. M. 3 phase, 70 amps. 25 cycle, furnishes power for briquette press only.
5. 5 H. P. Westinghouse motor, 1420 R. P. M. 25 cycle, 550 volts, runs binder pump only.

Coal Consumption.

5 tons steam coal are used by the steam shovel and boilers in 24 hours. Six tons of oversize from the screen are used in the dryer furnaces.

Men employed.

4 men in office,	1 man at press.
4 men on steam shovel — 2 shifts.	2 men in briquette bin.
3 boiler firemen — 3 shifts.	2 men bagging.
2 foreman.	1 machinist.
3 men at dryer feed.	1 electrician.
1 man firing dryer.	1 carpenter.
1 man at mixer.	1 truckman.
1 man at fluxer.	10 labourers.

TESTS CONDUCTED.

Test of Dryers.

The capacity of each dryer was determined by the amount of coal delivered at the feeder. This was found to be 28,400 pounds per hour which does not include the oversize taken out by the screen. The amount of material in the dryer at any one time, on this basis, is 2.2 tons, to which must be added the percentage of oversize.

An attempt was made to determine the efficiency of the dryers, but the sample obtained was not satisfactory. The analysis of the raw coal shows a total water content of 11.8 percent, and the dried undersize 2.9 percent.

Test of Crushing undergone by Coal in Edge Runner.

A sample of the material after passing through the edge runner was taken for the purpose of determining the amount of grinding done by this machine. The material was freed from binder by extraction with carbon bisulphide and a screen analysis made. As shown in the accompanying curve (A) the material has undergone considerable crushing, 8.8 percent passing through a 200 mesh screen as against 0.2 percent on the dried undersize. See figure 8-h.

Test of Physical Condition of Charge to Press on Quality of Product.

An attempt was made to secure definite information with respect to the best temperature for briquetting. The temperature of the material in the agitator above the press was varied and samples of the corresponding briquettes were taken and their density determined.

Temperature — Density table.

Temperature of feed. Degrees FAHRENHEIT.	Density.
132	1.326
136	1.340
140	1.311
145	1.333
150	1.331
153	1.343
155	1.338
158	1.328
158	1.333

Test on Effect of Water Cooling on Briquettes

Samples of the briquettes were taken both before and after cooling in the water trough and their moisture content determined. The increase in moisture due to immersion was found to be negligible.

Briquettes before water bath percent moisture	3.0
Briquettes after water bath percent moisture	3.7

Tests of Time of Flow and Temperature Material Through Plant.

The time required for the coal to pass through the dryer was determined by means of an identifier. A block of wood 9 x 3 x 3 inches was dropped into the chute and 9 minutes elapsed before it appeared at the discharge end.

The time required for the material to go through the edge runner was determined roughly by stopping the feed and timing complete discharge. The time required was 3½ minutes.

Temperatures

Discharge of dryer	180 degrees FAHRENHEIT.
Air from the fan	147 " "
Binder at discharge pipe	260 " "
Helical mixer discharge	170 " "
Fluxer discharge	180 " "
Material after edge runner	122 " "
Material in agitator	135 " "
Before water tank	135 " "
After water tank	119 " "

The temperature of the rolls in the briquetting press is barely perceptible. They are not cooled but by alternating the feed to the press a low temperature is maintained.

CHEMICAL ANALYSES

*Original Coal.**

	SAMPLE A.		SAMPLE B.	
	as received %	dry %	as received %	dry %
Moisture	2.3		3.7	
Vol. Matter	7.5	7.7	7.8	8.0
Ash	21.9	22.4	21.8	22.6
Fixed Carbon	68.3	70.0	66.7	69.3
Calorific Value	11065	B. T. U. per pound.		

Dried Coal†

	as received %	dry. %
Moisture	2.9	
Volatile matter	8.0	8.2
Ash	21.0	21.6
Fixed Carbon	68.1	70.2
Calorific Value	11,083 B. T. U. per pound.	

Briquettes.

	As received %	dry. %
Moisture	3.0	
Volatile matter	10.7	11.0
Ash	20.2	20.8
Fixed Carbon	66.1	68.2
Calorific Value	11,414 B. T. U. per pound.	

In view of the high ash content a washing test was made on sample A. A solution whose specific gravity was 1.5 was selected because its specific gravity approximates the density of the most impure coals that can be profitably burned for commercial purposes.

Sink and Float Test on SAMPLE A.

Specific Gravity Solution	1.5
Percentage of Float	60.6
Percentage of Sink	39.4
Ash in Float	10.8
Ash in Sink	41.0

Binder

The melting point of the binder used was determined by the ring and ball method from a sample secured from the binder feeder pipe.

Melting point of Binder..............145 degrees FAHRENHEIT.

*Samples were air dried before analysis.
†After removal of oversize for use in furnace.

Screen Analysis.

A screen analysis was made of the raw coal, the dried undersize and the coal after passing through the edge runner. The tables and curves are shown on Fig. 8-h.

CONCLUSION.

(1) It is evident from the sink and float test on the raw material that the installation of a small washing plant at the place where the coal is obtained, would be instrumental in reducing considerably the ash content of the coal and a much higher grade fuel could be made. This would also save freight on a large weight of material which is worse than useless. It might also be advisable in view of the analysis of the raw material to keep chemical control on the quality of the coal received.

(2) Considering the amount of crushing undergone in the edge runner we are inclined to believe that this machine tends to increase the amount of binder required; as theoretically, the larger the number of particles to be coated with binder the greater the amount of binder necessary. On the other hand it is quite possible that a proper proportioning of coarse and fines has been accomplished, thereby reducing to a minimum the voids which would have to be filled with binder.

(3) The results obtained on the best briquetting temperature as shown in the Temperature — Density Table, are not entirely satisfactory owing to the number of variable factors which cannot be controlled such as the amount of material in the agitator, pressure, etc. The table shows however, that the tendency is toward greater density with higher temperature, the maximum being reached at 153 degrees Fahrenheit. This is in accord with our experimental results at Ottawa. The present temperature employed averages 132 degrees Fahrenheit and we would suggest that this be increased. It is quite possible that an increase in breakage would result from this practice which would offset the benefits, but definite proof of this could only be determined by trial over an extensive period

In conclusion the writers wish to express their appreciation of the treatment they were accorded by all members of the staff with whom they came in contact. Every assistance was rendered them by Mr. F. H. Slater, President of the Nukol Co., Mr. Fletcher, Plant Manager, and Mr. Williams, the General Briquetting Co's representative at the plant.

REPORT ON VISIT TO ANTHRACITE BRIQUETTE CO., PLANT, TORONTO, ONT.

The capacity of this plant is 10½ tons per hour, operating 24 hours per day. The Gambite process, a binder of sulphite liquor and hydrolene, combined, is used.

The coal is taken from storage outside by a drag chain into an elevator boot.

A bucket elevator at 45° slope, about 50′ centres conveys the coal to a 7/8″ square mesh screen 8′ long, 3′ diameter, trommel type, over the dryer. The oversize is used in the boilers and dryer furnace. A straight chute carries the screened coal into the dryer.

The dryer is 45′ long, 4′6″ diam., made of ¼″ plate insulated with asbestos, travelling at 8 R. P. M. slope ¼″ to 1 foot. It is fired from a furnace at the high end, with a suction fan at the low end. The coal takes 7 minutes to pass through the dryer.

The dried coal is elevated by a bucket elevator at 40° slope, 15′ long to a chute to the pulverizer of K.-B. type. The top of the pulverizer is 6′ from the floor.

The pulverized coal is conveyed by a 45° scraper conveyor 30′ centres to a 20-ton vertical fluxer, set about 10′ from the floor. Hydrolene and sulphite liquor are added through pipes in the fluxer. These binders are pumped up separately, and the required amount, once it is found by experiment, is kept constant by conical pulleys on the pump. The quality of the mixture is judged by a man at the fluxer. The mixture is discharged from the fluxer into a 16″ helical conveyor type horizontal mixer, 10′ long, which discharges the mixture into a hopper over the press.

This hopper has four scraper arms at the bottom revolving on the centre axis.

The briquette press is Belgian Roll type, 15 ton capacity, making a 2 oz. briquette.

The briquettes are discharged from the press on to a rocking bar screen actuated by a cam from the press shafting, from which the fines are carried by a belt conveyor to a small bucket elevator to the press hopper. The briquettes slide from the rocking screen on to a 200′ centres cooling belt, 24″ wide, at 20° slope, to the briquette storage bin of 600 ton capacity. This bin has 6 compartments with a belt conveyor running the full length. The power is electrical, furnished by two 100 H. P. motors.

Binders.

Hydrolene 140° F. melting point. The binder tank cars are unloaded in a heated shed. Hydrolene is pumped into an 8000 gallon, horizontal, cylindrical tank having steam coils on the bottom, and suction directly above the coils.

The sulphite liquor is unloaded cold. It is discharged into a similar storage tank, without steam coils.

This plant seemed to the writers, to be quite efficient.

The cooling belt does not give enough cooling, but the briquettes are allowed to season for a day or two in the storage bin.

Only four men are employed in the plant proper. This includes a foreman, briquette man, 2 boiler firemen.

Analysis of A. B. C. Briquettes.

	As rec'd %	Dry Basis %
Moisture	1.4	
Vol. matter	17.1	17.3
Ash	13.3	13.5
Fixed carbon	68.2	69.3
Calorific value	12,172 B. T. U./lb.	

APPENDIX No. 29

Brief Description of the Carbonizing and Briquetting Plant at the North Dakota Mining Experiment Sub-Station, at Hebron, N.D.

By R. A. STRONG.

The plant is situated at Hebron, N. D., a small town in the central western portion of the State. There are several mines in the vicinity of the town from which coal can be readily obtained, but as the plant is located at some considerable distance from the railway, all the coal must be teamed.

DESCRIPTION OF PLANT

The buildings, of brick with wooden roofs covered with some patent roofing material, are comparatively new and in good condition. The plant comprises a retort house in which is included a small boiler room; a briquetting building; a storage bin, and an office building. The yard is equipped with track for small cars which are moved by hand.

The briquette produced is pillow shaped and weighs about 1½ ounces, flour and pitch being used as binder. The capacity of the briquetting unit is 25 tons per 10 hour day but this is dependent on the carbonizer which has a capacity of 20 tons of lignite per 24 hours.

COAL HANDLING AND STORAGE

The raw lignite is brought in by rail from the various mines throughout the State, as it is the purpose of the station to test the coal from all the different developments in order to determine which coals are the most suitable for carbonizing and briquetting. It is teamed from the railroad to the plant in wagons and is shovelled into a concrete bin. A roll crusher is available for crushing in the event of smaller sizing being desired. At the time of the writer's visit this was not being used and lumps up to six inches were being fed to the retort.

An elevator carries the coal from the storage bin to a bin slightly above the charging floor of the retort. It is then fed by hand into a dump car which passes over a scale where the coal is weighed, and then dumped into the charging hopper of the retort.

RETORT

The retort is of the by-product recovery type inclined at an angle of 45 degrees. It is composed of six double chambers 16′ 4″ x 30″ x 8″ superimposed, with heating flues on top and below and a common charging hopper. There are three gas offtakes provided although the lower two are at present only being used The retort is constructed of fireclay shapes resting on concrete foundations. The cooling chambers are vertical and the hot char is cooled by air flues which preheat the air before it goes to the combustion flues. The cooling chambers are 2′ x 30″ x 8″ and are discharged by a revolving star wheel feeding a screw conveyor. The discharge is intermittent. Figure No. 51 shows a diagrammatic elevation of the retort.*

The gas from the lower and intermediate offtakes is taken off by means of 4″ standpipes which dip into a standard hydraulic main installed by the Cleveland Gas Co. It then goes to a large cooler, which is an old coverted boiler, and then through two vertical scrubbers where the tar is removed. The clean gas is fed direct to the combustion flues, a burner being provided in the first three of these. A small positive pressure Sturtevant exhauster is used for extracting the gas. A bypass bell governor regulates the pressure.

The gas from the upper offtake is drawn off by another small Sturtevant blower, is conducted through a similar train of scrubbers and is then burned under the boilers. This use is made of the gas, (mostly CO_2 and water vapor) on account of its very low heating value. A small gas producer is provided which is used for heating up the retort, but this is not used when the retort is operating. The gas from the coal being treated is sufficient for carrying on the process but there is no excess.

The residue when discharged from the retort is elevated to a bin above the charging floor and is discharged into dump cars and weighed. It is then dumped by means of a chute on a storage pile outside of the building. From here it is loaded into small cars and moved by hand over to a bin outside of the briquetting building.

BRIQUETTING INSTALLATION

The briquetting building is 30′ x 40′ outside dimensions, being 15′ above grade and 10′ below The plant is divided into three departments, i.e.; crushing, mixing and briquetting†, a flow sheet of which is shown in Fig. 52.

Crushing.

The residue bin is a double compartment bin, one side of which is used for coking coal. These compartments are of 2 and 1-¾ ton capacity respectively. A double plunger feed mechanism of standard design delivers the coal from these bins to roll crushers. The speed of the plungers determines the amount of coal fed. It is customary at this plant to use about 10% of bituminous coal in the briquette, although briquettes of excellent quality have been made without this addition. The bituminous coal adds to the coking properties of the briquettes and makes them harder during burning.

The first is a crusher Sturtevant 12″ x 12″ smooth roll operating at a speed of 150 r. p. m. The amount of reduction obtained with this machine is shown on the curve, Fig. No. 8b. The crushed coal is delivered to a screw conveyor which empties into an elevator boot.

The top of this elevator is connected to a No. 6 C.I. exhauster fan which removes a considerable portion of the dust carrying it to a cyclone dust collector located outside of the building. The discharge from the elevator is to a second pair of Sturtevant rolls 22″ x 10″ operating at a speed of 200 r. p. m. These rolls crush the coal down to the proper size for briquetting and deliver it to the crushed coal storage bin which has a capacity of 2½ tons. Fig. No. 8b gives the screen analysis of the material as briquetted

*A drawing of this carbonization plant can be found in U.S. Bureau of Mines Bulletin No. 221, Page 26.

†Photographs of this plant will be found in U. S. Bureau of Mines Bulletin No. 221.

Mixing.

The crushed coal is delivered from the residue bin to an elevator boot by means of a Gauntt feeder which allows of very fine adjustment. A small flour bin is located beside this elevator, and a Gauntt feeder delivers the flour into the elevator where it is mixed with the coal. This feeder allows of very close regulation, each tooth on the ratchet corresponding to ¼%. It is customary to use about 1½% of flour in the briquettes. This materially reduces the pitch necessary and as a consequence the briquettes are much less smoky. The coal and flour mixture is then elevated to mixer No. 1 called a "*preheater*". This mixer is a horizontal steam jacketed machine with paddle arms revolving on a central shaft. It is 10″ x 10′ and has been made to an original design. It is operated at a speed of 100 r. p. m. Steam at 80 pounds pressure is circulated through the jacket and a small ½″ pipe line introduce steam at the same pressure into the mixer. The live steam in the mixer serves to moisten the coal and convert the flour into a paste. It also brings the coal to the proper temperature for the addition of pitch. In this respect it is very efficient as a rise of 80 degrees F. was noted in the temperature of the mix, which is next discharged to a second horizontal mixer of similar design. This machine called a "*mixer*" is somewhat larger being 12″ x 12′ and is operated at 100 r. p. m. Steam is used in the jacket of the mixer but none in the mix. Very little heat is gained during the passage through the mixer. Pitch binder is added as the coal enters the machine.

The discharge is to a third horizontal mixer of similar design called a "*cooler*. This machine is 12″ x 12′ operated at a speed of 50 — 60 r. p. m. All three mixers are connected to a stack but in the case of the cooler a connection has been made to the fan. The ends of the cooler are removable and in this way a draft of air is circulated through the machine which reduces the temperature to the desired point for briquetting.

Binder System

The binder system consists of two rectangular shaped tanks, one directly beneath the other. Both are open and contain steam coils for heating the pitch. The pitch is received in barrels and is dumped directly into the first tank. When it becomes liquid it is discharged into a second tank where the temperature is equalized. A small pump delivers it from the second tank through an 1¼″ pipe to the "*mixer*". A 3/8″ steam pipe is inserted at the nozzle in order to atomize the pitch and spray it on the incoming coal. The pitch pump is a small Rockford water pump having a maximum speed of 7 r. p. m. It is connected to a Reeves variable speed transmission which allows of speed adjustment.

Briquetting

The discharge from the "*cooler*" is directly above the press and the mixture is allowed to drop into a small hopper where it is fed continuously to the rolls. The briquettes are removed by means of a belt conveyor which carries them to a continuous bucket elevator. The discharge from this elevator is to an inclined grid which removes the fines and the finished briquettes pass on to an adjustable belt conveyor which distributes them in the bin.

The bin is a circular structure made of brick and hollow tile. The hollow tile forms perforations in the sides of the bin and allows a current of air to circulate. This assists in cooling and prevents mould which is liable to form when flour is used if the briquettes are not sufficiently cooled.

POWER AND PROCESS STEAM

Power is supplied from the town power plant at 2300 volts 3 phase 60 cycles and is transformed at the plant into 220 volts 3 phase 60 cycles for power purposes and 110 volts single phase for lighting. There are two Western Electric 35 H. P. 900 R. P. M. 220 volts 3 phase 60 cycle motors one driving the crushing equipment and the other the mixing and briquetting. These are ordinary standard motors and possess no special features.

Steam is supplied by a 50 H. P., H. R. T. boiler in the carbonizing building. The working pressure varies between 80 and 100 pounds per sq. inch. About two tons of lignite coal are used per 24 hours but as some steam is used for heating the building it is difficult to estimate the amount required in the briquetting process. Steam is used in the following places:—

1. Small coil in each binder tank.
2. 1-½″ spray in preheater.
3. 1-½″ spray in binder discharge pipe.
4. Steam jacket in mixer.
5. 1-½″ steam jet exhauster for mixer.
6. 1-3/8″ jet used occasionally in binder piping.

MEN EMPLOYED

2 men on carbonizers per shift — 3 shifts.
1 man on briquetting per shift — 1 shift.
2 men in yard per shift — 1 shift.
1 supervisor.

TESTS CONDUCTED

Even though this report is a description of a plant, and not strictly an operating record, it may be well to record some tests conducted and give some operating data obtained in February 1923, in order that it may be compared with similar results obtained at the same plant 9 months later,* when using char shipped from Bienfait.

Test on Temperature of Material Through Plant.

Temp. of residue after crushing	82° F.
" after Preheater	162° F.
" " Mixer	162° F.
" " Cooler also briquetting temperature	155° F.
" of Pitch	250° F.

*This test is described in Appendix No. 30.

Test of Crushing effected in each Roll Crusher.
Screen Analyses

Mesh	Residue%	After 1st Crusher%	After 2nd Crusher%
On 4	52.4	1.0	0.0
6	21.4	3.0	0.0
8	14.2	9.8	0.0
10	5.8	19.8	2.4
14	2.3	14.0	7.5
20	1.0	15.4	15.1
28	.5	8.8	15.1
35	.4	8.9	14.8
48	.3	7.8	10.4
65	.3	5.5	8.9
100	.3	3.0	8.5
Through 100	1.1	3.0	17.3

These results are shown plotted on curve Fig. 8b.

Chemical Analysis of Briquettes.

Moisture	7.3%
Vol. Matter	19.2
Ash	11.8
Fixed Carbon	61.7
Sol. in C. S_2	9.9
B. T. U./lb	11,182
Density (average of 10 Briquettes)	1.244

Test of Burning Qualities

A barrel of the briquettes was forwarded to Bienfait where they were burned in an open grate and observations made on their burning qualities. The briquettes were found to give off very little smoke and were exceptionally strong in the fire. They did not burn too rapidly and no evidence of sparking or cracking in the fire could be detected.

Conclusion

The outstanding feature of the installation at Hebron is its simplicity and ease of operation. A very small staff of men is required to operate the plant and even these could be materially reduced by the use of automatic handling machinery.

The retort is of very sturdy construction and apparently stands up very well under ordinary operating conditions.

The briquetting layout is a very efficient smooth running installation. One man is all that is required within the building and he is able to control the three departments i.e., crushing, mixing and briquetting. All feeding devices are very closely regulated and capable of fine adjustment.

A notable feature is the entire absence of dust and steam in the building. The result of this is that no trouble is experienced with belts or motors. The mechanical details have been very carefully worked out and the result is a very efficient plant.

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APPENDIX No. 30

Report on Briquetting Tests at Hebron, N.D., Decmber 1923.

By R. A. Strong

In accordance with the request of the Dominion Government, 125 tons of char containing from 10 to 20% volatile and 25 tons of char containing from 20 to 30% volatile was shipped to the Mining Experiment Sub-Station, Hebron, N.D., for a briquetting test. The objectives of the test were:

(a) To determine whether the char as produced during normal operations in the vertical shaft oven erected at the demonstration plant of the Lignite Utilization Board would present any peculiar difficulties in briquetting.

(b) To determine whether a satisfactory briquette could be produced from a char containing a somewhat higher volatile content.

(c) To determine whether lignite pitch as made from the tar recovered in the above mentioned installation, could be utilized as a binder.

(d) Obtain all information possible in regard to plant operation.

(e) Make all chemical and physical tests necessary to determine the quality of the briquettes produced.

(a) — TEST ON NORMAL CHAR.

The char selected for this experiment had been produced some months previously, and had been stored in one of the concrete storage bins. The reason for selecting this material in preference to some freshly carbonized char, was due to the increased fire hazard in shipping the latter. The rapid deterioration of char in storage, due to the absorption of oxygen, makes this material considerably inferior for briquetting purposes than that which has been freshly carbonized. The necessity for thorough wetting in order to prevent burning also contributes to a more rapid deterioration while in storage. It is to be regretted that freshly carbonized char could not have been selected in order that the briquettes produced would have represented the best results obtainable. On the other hand if stored char will produce a good briquette it can be confidently stated that better results can be expected from a commercial plant where the char is briquetted soon after being discharged from the retorts.

The char was subjected to considerable loss in dust and fines between the plant and the final briquette, owing to the necessity for several handlings. The result of this is a considerable difference in the chemical analysis of samples taken previous to shipment and of samples taken during briquetting operations.

In a previous report* a table showing the analysis of the different screen sizes of char is included. This reveals the fact that the degree of carbonization is greater in the finer sizes than in the larger, and hence a loss of fines causes a material difference in analytical results.

The mechanical operation of the plant during the briquetting of this char was in all respects comparable to the results previously obtained using a char produced in the inclined retort, designed by the University of North Dakota and installed at the Hebron Experiment Station. The only difference noted was that the char from the Lignite Utilization Board's plant seemed somewhat softer than that produced at Hebron. This resulted in finer grinding, less power required for grinding, smoother surface on the briquettes (due to the altered screen analysis) and a higher binder requirement.

Flour and coal tar pitch were used as a binder and it was found that 2% of the former and 10% of the latter were necessary for a strong briquette. This is higher than was anticipated but it is quite possible that with fresh char containing a somewhat lower percentage of volatile matter the amount of pitch could be considerably reduced.

In conclusion it may be stated that the char produced in the vertical retort as erected at the Lignite Utilization Board's plant does not offer any new problems in briquetting. The entire absence of mechanical troubles during the test has demonstrated that a duplication of this installation would operate smoothly and efficiently and produce a high grade product on a commercial scale.

(b) — TEST ON HIGH VOLATILE CHAR.

In order to determine whether briquettes could be made from high volatile char without undue difficulty, 25 tons of char containing from 20 to 30% of volatile matter were shipped to the Hebron plant. The argument advanced in favour of a test of this nature was that by leaving a higher percentage of volatile matter in the char, a greater yield could be obtained without materially sacrificing the quality of the product. The higher yield would also materially reduce the cost of the briquette.

The disadvantages of operating the retorts under these conditions has been discussed in Appendix 27, so that further comment here is unnecessary. Suffice it to say that this kind of operation is attended with certain disadvantages which do not make for real economy.

In order to produce this high volatile char it is necessary to discharge from the retort at a very rapid rate and as a consequence some of the lignite passes through without being carbonized at all. This raw coal gives trouble in the crushing operation by "plating" on the rolls. These "plates" do not always break up and are liable to cause weakness in the briquettes.

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*See appendix No. 27.

During the operations it was noted that the high volatile char has a tendency to "surface pit". This is due to the mix being somewhat sticky and not clearing properly from the rolls. In every other way operation was entirely normal and no additional binder was required to make a satisfactory briquette.

In conclusion it can be stated that from a mechanical standpoint no difficulties stand in the way of making a briquette from relatively high volatile char. This is contrary to expectations and is highly gratifying in view of the wide range it allows the operator to carry out the carbonizing operation. It is probable that these briquettes will not stand storage as well as those containing less volatile but for immediate consumption, this is not an objection.

(c) — TEST USING LIGNITE PITCH AS A BINDER.

In a commercial plant using the vertical retort installation a large quantity of tar is recovered which at present can only be utilized as a fuel or distilled and used for fuel oil and binder. It is essential therefore to know whether the pitch from this tar will mix properly with the pitch as obtained from gas works tar, and produce a good briquette.

In order to determine this question a small still was erected at the Bienfait plant and sufficient tar distilled to obtain enough lignite pitch to briquette a car load of char. It was estimated that the quantity obtainable in a commercial plant is equal to at least 20% of the requirements. It was therefore mixed in this proportion.

No separation of the lignite pitch was noticed in the binder tank so no difficulty may be anticipated on this score. The lignite pitch will displace the coal tar pitch as a binding agent in equal proportions and in view of its more oily nature the indication is that it reduces any tendency of the "mix" to stick in the rolls.

In conclusion it can be stated that the tar can be utilized in this way and a considerable saving thus made in binder costs.

(d) — OPERATING DATA.

During the operation daily tests were made as to quantity of binder used, temperatures of the mix in the various machines, speed of machines and percentage of fines. As these details have an important bearing on the smooth operation of a plant, an average of the results of these tests is given below.

Quantity of Binder Used.

	% Binder	Mixing Ratio
Flour	2%	2
Pitch	10%	11

Temperatures.

Temp. of coal	70°F.
Temp. after preheater	195°F.
Temp. after mixer	185°F.
Temp. after cooler (also briquetting temp.)	155°F.
Temp. of pitch	264°F.

Speed of Machinery.

	Speed	Size	Tangential Speed
Crushing Rolls	183 R.P.M.	12″ x 12″	575′ per min.
Preheater	...	10″ x 10′	
Mixer	99 "	12″ x 12′	
Cooler	54 "	12″ x 12′	
Press	6.84 "	Mashek—22″ rolls	39.3′ per min.
Binder pump	6.22 "	Rockford No. 3 water pump.	

Percentage of Fines.

In order to gain information for estimating the amount of material to be rebriquetted in a commercial plant tests were made on amount of fines passing through the press. The average of several tests was — 3.8%.

These fines are due to the breaking off of fins on the briquettes and the small amount of material which passes through the press without being briquetted. No account has been taken of the breakage which will occur in the bin but an estimate of 3% is made for this.

It can be stated that the total amount to be rebriquetted will not exceed 7% with proper operation. This figure is the same as determined in previous operation at the Hebron plant.

(e) — TESTS CONDUCTED ON CHAR AND BRIQUETTES.

In order to determine the quality of the briquettes produced, samples were collected at intervals daily of both char and briquettes. These samples were forwarded to the, laboratories of the School of Mines of the University of North Dakota, Grand Forks, where exhaustive tests were carried out. The nature of these tests was as follows:—

(1) Analysis of char as loaded.
(2) Analysis of char as briquetted.
(3) Screen analyses of char as received; after passing through first set of rolls and after passing through second set of rolls.
(4) Analysis of briquettes.
(5) Miscellaneous analyses.
(6) Drop test on briquettes.
(7) Stove test with briquettes.

The results of these tests are given below.

(1) *Average analysis of char as loaded at Bienfait.*

	10-20% Vol.	10-20% Vol. Dry Basis.	20-30% Vol.	20-30% Vol. Dry Basis.
Moisture	9.7	....	13.5	....
Vol. matter	13.9	15.4	23.5	27.2

(2) *Average analyses of char as briquetted at Hebron.**

	10-20% Vol.	10-20% Vol. Dry Basis.	20-30% Vol.	20-30% Vol. Dry Basis.
Moisture	15.6	....	15.4	....
Vol. matter	17.3	20.5	28.3	33.4
Fixed carbon	54.3	64.3	45.0	53.2
Ash	12.8	15.2	11.3	13.4
B.T.U. per lb.	9,027	10,692	8,753	10,340

(3) *Screen Analyses.*

The curves, Fig. 8, *c, d, e,* show the plotted results of this test. A comparative curve is inserted which represents results obtained in this connection with char as produced in the inclined retort at the Hebron Station. As the screen analysis has a direct bearing on the strength of the briquette it is important that a standard should be adopted and in plant operation attempts made to conform to this standard as closely as possible at all times in order to produce a uniform product.

(4) *Analysis of Briquettes.*

	10-20% Vol.	10-20% Vol. Dry Basis.	20-30% Vol.	20-30% Vol. Dry Basis.
Moisture	11.4	....	8.6	....
Vol. matter	22.7	25.6	33.9	37.0
Fixed carbon	55.0	62.1	47.8	52.4
Ash	10.9	12.3	9.7	10.6
B.T.U. per lb.	10,156	11,462	10,307	11,275

(5) *Miscellaneous Analyses.*

Miscellaneous proximate analyses of materials used in the briquetting tests at the Mining Sub-Station at Hebron in Dec. 1923.

*See table in Fig. 44.

Fines from dust collector.

	As received	Dry Basis
Moisture	12.00	.....
Vol. matter	19.10	21.70
Fixed carbon	54.65	62.10
Ash	14.25	16.20
B.T.U. per lb	9,313	10,583

Flour used as binder.

	As received	Dry Basis
Moisture	11.88	....
Vol. matter	68.92	78.20
Fixed carbon	17.83	20.25
Ash	1.37	1.55
B.T.U. per lb	6,926	7,860

Pitch used as binder.

	Coal tar pitch	Lignite pitch	20% Lignite pitch 80% C.T. pitch
Moisture	.78	.83	.79
Vol. matter	66.59	76.02	64.52
Fixed carbon	32.51	22.63	34.50
Ash	.12	.52	.19

(6) *Drop Test.*

The method of making the drop tests is the same as described in U.S. Bureau of Mines Bulletin No. 221 (Babcock and Odell) pages 71 and 72.

"The apparatus for making these tests consisted of a tight wooden enclosure 18 inches square at the base reduced to 8 inches square at the top and 6 feet high. The top terminated in a small reservoir and a double drop gate so arranged that the whole charge of coal could be simultaneously released and dropped. The coal struck on a 2-inch cement slab fitted tightly to the bottom of the drop box. Each charge of coal or briquettes tested weighed 10 lbs. and was sized to pass a 2-inch ring but not a 1½-inch ring. Each charge was dropped five times. It was then screened into the sizes given in the table, different sizes weighed, and the percentage of each computed."

This test, in a measure represents one of the conditions of handling. The following data on drop tests indicates the relative strength of the three types of briquettes made at Hebron, N.D. An average of the results of eleven drop tests on briquettes from North Dakota lignite at the Mining Sub-Station, Hebron, in 1921, as shown in Bureau of Mines Bulletin No. 221, is included by way of comparison.

Lot No. 1 represents briquettes made with 2% flour and 10% of pitch having a volatile content between 10 and 20%.

Lot No. 2 represents briquettes made from similar char using the same quantity of binder but in which 20% of lignite pitch has been mixed with the coal tar pitch.

Lot No. 3 represents char with a somewhat higher volatile content, i.e. 20 to 30% made with 2% flour and 10% coal tar pitch as binder.

Lot No. 4 is an average of eleven drop tests of briquettes made from N. D. lignite at the Mining Sub-Station, Hebron, in 1921.

Results of Drop Test.

Screen Sizes

Lot No.	On 1½″	On 1¼″	On 1″	On ¾″	On ½″	On ¼″	Through ¼″
1	92.18	1.25	.47	.63	.94	.94	3.59
2	86.88	1.87	1.56	.94	.94	1.56	6.25
3	90.93	1.56	1.56	.63	.94	.63	3.75
4	95.29	.45	.11	.34	.40	.45	2.96

From the above table it is seen that degradation is chiefly from abrasion. While the percentage of breakage in briquettes from the Canadian char is higher than that shown for the average of eleven samples of briquettes from N. D. lignite, the briquettes are amply strong to withstand all reasonable handling.

The briquettes made with a mixed binder of lignite pitch and coal tar pitch are somewhat weaker than those made with coal tar pitch alone. Because of its more oily nature the lignite pitch apparently tends to keep down the fine dust from handling, possibly a little lower even than that from the briquettes made with standard coal tar pitch.

The high volatile briquettes stood handling reasonably well but showed a greater tendency to abrasion and surface pitting than the others. This roughening of the surface permits more rapid deterioration in weathering.

The briquettes were tested rather early after being made and have not reached their maximum of hardness. They show up very favourably for the length of time they have had to harden and can be considered as sufficiently strong to withstand the normal handling required.

(7) *Stove Test on Briquettes.*

The following table gives the results of the stove tests from the three varieties of briquettes made during the December test. A description of the method used for making this test is taken from U. S. Bureau of Mines Bulletin No. 221 (Babcock and Odell) pages 69 and 70.

"The tests were made in a room specially built for the purpose in a basement and partitioned off within a much larger room that was kept at a uniform temperature. This testing room was connected by an ordinary stove pipe with a chimney having adequate draft. Provision was made for the inlet of air through ordinary registers near the floor. Self recording thermometers were used to take the temperature of the room at the beginning and throughout the test and to determine the temperature of the flue gas. The temperature outside of the room was kept normal and the drafts were regulated so as to permit the same flow of air in each test. 60 pounds of briquettes were used in each trial and uniform conditions were maintained in all the tests. The amount of normal ash, percentage of unburned carbon in the ash, and the percentage of briquettes unburned were determined in each test."

The room temperature curves as shown on the attached diagrams, Fig. 45, *a to h* inclusive, have the characteristic form for carbonized lignite briquettes. The enclosed areas being approximately proportional to the heat value of the materials burned. The briquettes held their shape and maintained a reasonable strength in the fire although no coking coal was used. While the volatile content in all of the briquettes was rather high, the combustion rate, except in the high volatile briquettes, was no higher than in some of the low volatile briquettes previously made at the Mining Sub-Station at Hebron. This was due probably to the higher moisture content and finer grinding of this softer char.

The high volatile briquettes gave a longer flame and showed a tendency to burn faster than the lower volatile product, a more rapid falling off of temperature after the maximum was reached, and a greater duration of the effective fire. The contributing factor in the higher combustion rate was the coarser particles in the briquettes due to the inability to crush the uncarbonized material uniformly. Some sparking in the fire was also observed during the burning. The percentage of combustible in the ash was relatively low except in stove test No. 6 which was closed at the end of 12¼ hours. If the test had been continued until the material in the grate had burned out, the combustible in the ash, would also have burned out much more completely.

In stove test No. 13 (see Fig. 46) on a larger quantity of similar material (except for a higher moisture content) the combustible in the ash was low. The high percentage of combustible in the ash from the stove test No. 6 shows the tendency for this particular lot of briquettes to disintegrate somewhat in the fire. This probably can be charged to the relatively high volatile content rather than to the use of lignite pitch as a part of the binder in this particular test. In a later test, briquettes made from lower volatile content with all lignite pitch binder and no coking coal stood up well in the fire.

As a matter of comparison, a table taken from U. S. Bureau of Mines Bulletin No. 221 (Babcock and Odell) is included showing the results of similar stove tests using anthracite coal. The analysis of the anthracite used in these tests is as follows:—

Moisture	.3%
Vol. matter	5.4
Fixed carbon	81.6
Ash	12.7
Cal. value	12,035 B.T.U. per lb.

Results of Stove tests showing available heat for Anthracite Coal and Lignite Briquettes.

Kind of coal	Available heat per lb. of coal consumed. In degree hours	Ash from stove test %	Combustile in ash %
Anthracite....................	14.87	23.66	.....
"	15.65	17.57	.....
"	11.90	21.06	30.81
"	13.52	20.10	31.09
"	14.71	20.54	23.62
"	17.44	21.15	.....
"	12.42	14.81	20.63
Average.....................	14.36	19.84	26.54
(5) Lignite briquettes (normal char).....	17.00	11.02	3.52
(6) " (lignite pitch experiment).....	16.41	10.45	13.27
(13) " "	14.97	9.58	.55
(7) " (high vol. char)....	15.61	9.22	.50
Average.....................	16.00	10.07	4.46

It will be noted that the lignite briquettes give decidedly more available heat per pound than the anthracite. One of the most notable differences between the two fuels is the relatively low amount of unburned matter left in the ash from the briquettes. It is a characteristic of carbonized lignite briquettes to burn almost completely to ash whereas anthracite always leaves much unburned carbon in the center lumps with pieces of ash and cinder. From the above tests it will be noted that the briquettes as made during this test give every evidence of being a very satisfactory fuel as judged by commercial requirements. The diagrams (see Figs. 45 and 46) show in greater detail the results of these tests.

SUMMARY.

(1) 125 tons of char containing volatiles between 10 and 20% have been briquetted at the Hebron station.

(2) 25 tons of char containing between 20 and 30% volatiles have been briquetted.

(3) No mechanical difficulties were encountered during entire run.

(4) Binder necessary was found to be 10% pitch and 2% flour. (This is 11 and 2 in terms of mixing ratios.)

(5) No difference was noted between straight C.T.P. briquettes and those containing 20% lignite pitch mixed with C.T.P.

(6) No great difference was noted in mechanical operation between different chars.

(7) Close regulation of temperatures is necessary as well as control of feeds for uniform product and minimum of trouble.

(8) High volatile briquettes show weakness in fire also rapid ignition and combustion.

(9) In order to get best results char should not be stored before briquetting, for any length of time.

(10) Deterioration of char is rapid.

(11) Char from internally fired oven not as hard and does not produce quite as good a briquette as that from the inclined setting as used at Hebron.

(12) Lignite pitch seems to eliminate any tendency for sticking in rolls.

(13) Screen analyses shows higher percentage of fines. This makes a smoother surface but requires more binder.

(14) Power requirements for grinding were lower than with the harder char.

(15) Briquettes produced can be considered of commercial quality.

(16) Fines did not show any increase over previous operation.

CONCLUSION.

The test has demonstrated that the char made in the vertical shaft carbonizer installed at Bienfait offers no new problems in briquetting. The char has several points of difference from that produced in the Stansfield carbonizer also from that produced in the Hebron retort but these differences do not present any obstacle in briquetting it. It has also been shown that good briquettes can be made from a high volatile char and while these briquettes do not show up as well in the physical tests as those made from a lower volatile char, it has demonstrated that the operating range in the production of char is wide, which is a decided advantage in commercial plant operation. The range of operation is solely dependent on the quality of briquettes desired.

The briquettes produced while not being of the best quality obtainable owing to the selection of the material to be briquetted, are a remarkably good product as judged by commercial standards. The stove or burning tests show them to be superior in some respects to anthracite coal.

Grateful acknowledgement is made to Dean E. J. Babcock and to Mr. R. L. Sutherland for the carrying out of this test, and for their kindly assistance in collecting the data desired by the Board.

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APPENDIX No. 31

Report on Briquetting Tests at Grand Forks, N.D., December 1923

By R. A. STRONG.

In order to supplement the tests made at Hebron, the results of which have been given in a previous report, three lots of char were sent to Grand Forks to be briquetted. It was considered that a great deal of information could be gained by a small scale test of this nature where accurate control of all possible variables is more readily attainable than in a larger plant.

SUMMARY OF RESULTS.

In the accompanying tables will be found the results of this test in tabulated form together with data covering stove tests, B.T.U. values, and analyses of the small lots of special briquettes made. A study of the tabulated results shows that the lower volatile char produces a superior briquette both physically and chemically and requires considerably less binder. It would therefore be better in commercial operation to work for this type of char in order to reduce the binder costs as well as raise the quality of the product.

Lignite pitch can be utilized as a binder but when it is used alone the briquettes are not as strong as when it is mixed with coal tar pitch. The mixture of 20% of lignite pitch with coal tar pitch does not materially weaken the briquette. The use of lignite pitch is beneficial in reducing the tendency of the "mix" to stick in the rolls, and also in eliminating the dust in briquette handling.

The high volatile briquettes in this test did not show up as well as in the Hebron test. This is due partially to the crushing system, which only includes one roll, and partially to the press which makes a larger briquette but does not give the same uniformity of pressure as does the press at Hebron. These high volatile briquettes are softer in the fire, and tend to break up, as will be noted by the high percent of combustible in the ash in the stove tests. The results of the entire test are not as favourable as those obtained during the Hebron test, due to the difference in the two installations, but they are, however, very instructive and may be summarized as follows:—

(1) A two ounce briquette is superior to a four ounce briquette, as greater pressure is given to the smaller size during fabrication. (This applies to the product of roll presses only.)

(2) Two sets of rolls are preferable in crushing as a more uniform screen analysis is obtainable and this results in a better briquette.

(3) Binder requirements are dependent on volatile content of char. The higher the volatile the more binder required.

(4) High volatile briquettes are not as strong in the fire as those made from a low volatile char.

(5) Lignite pitch can be mixed with coal tar pitch and thus utilized as a binder.

(6) Briquettes made with lignite pitch alone are not as strong as those made with the mixture of coal tar pitch and lignite pitch.

(7) The use of lignite pitch tends to eliminate dust in handling briquettes also decreases tendency for the mix to stick in the press rolls.

(8) The char as produced in the vertical retort installed at Bienfait does not offer any new problems in briquetting.

DISCUSSION OF RESULTS.

The tests were made at the School of Mines, University of North Dakota, Grand Forks, where a plant has been erected for demonstration purposes and small scale testing. The following is a description of the installation, a flow sheet of which is shown in Fig. 50.

The general principles of the layout are the same as those which have given success at the Hebron station. A small bin equipped with a Gauntt feeder is used for the storage of the char, while a smaller bin similarly equipped is used for flour. In the event of using coking coal in the briquette, the flour and coking coal are mixed by hand and fed in together.

The crushing equipment consists of a small gyratory crusher and one set of smooth rolls. The discharge from the rolls is to a crushed char bin.

The mixing apparatus consists of one long steam jacketed Gedge Gray mixer. The first half of the mixer is used for heating up the mix and "cooking" the flour, — live steam being injected in order to obtain the required temperatures. The binder is added midway in the length of the mixer. The feed is controlled by a Gauntt feeder and the discharge is controlled by a gate. By means of this latter regulation, the depth of material in the mixer can be regulated, which allows of more or less mixing as desired. The discharge from the mixer is to a bucket elevator which discharges into a Gauntt feeder. The purpose of this last feeder was for tempering but as it was not found to be satisfactory it has since been eliminated.

The briquette press is of special design and makes a four ounce briquette. These are discharged on a perforated belt which allows the fines to pass through to be later removed by hand.

Three lots of char were shipped from Bienfait which weighed approximately two tons each.

Lot No. 1 represented normal char having a volatile content between 10 and 20%.

Lot No. 2 represented a high volatile char having a volatile content between 20 and 30%.

Lot No. 3 represented char having a volatile content below 10%.

As in the test made at Hebron the char had deteriorated by having been stored before being briquetted. Analysis of the char and briquettes for each lot with the average composition of the briquettes made is shown in the table Fig. 47.

Lot No. 1. This char was rather high in volatile and carried a considerable proportion of uncarbonized or only partly carbonized lignite. As a result, the crushing, through only one set of rolls, was not uniform. The briquettes produced were not properly pressed, due in part to the lack of uniformity in size of the material, and in part, to the large size and the shape of the briquettes made by the press used.* These smaller tests, for several reasons, did not give as good results as those made in the larger experimental plant of the School of Mines Sub-Station at Hebron, and did not demonstrate as accurately as the larger test, the suitability of the material for briquetting. However, in both the tests at the University and at the Sub-Station (Hebron), the binder requirement was rather high, as would be expected with a high volatile char.

*Similar material was later made into strong briquettes of good surface at the Hebron Station.

On November 30 and December 1, the briquettes in these tests had the following mixture by weight:—

*Char (moist)	3,105 lbs.	80.52%
Coking coal	280 lbs.	7.27%
Pitch	402 lbs.	10.45%
Flour	68 lbs.	1,76%
	3,855 lbs.	100.00%

On December 5, a test was made on similar char using as binder, in addition to the flour, a mixture of 25 per cent lignite pitch and 75 per cent of coal tar pitch. In a second test the proportions were approximately 8 per cent lignite pitch and 92 per cent coal tar pitch. No noticeable difference in plant operation or binder requirement was found. A car load of similar char was later briquetted at the Sub-Station at Hebron using 20 per cent lignite pitch and 80 per cent coal tar pitch as already described in appendix 30. The only difference in plant operation noted was a reduced tendency for the mixture to stick in small lumps in the pockets of the press, probably due to the more oily nature of the lignite pitch or lower melting point, or both. The briquettes were a little weaker than those made with all coal tar pitch, as shown by drop tests of the briquettes made at the Mining Sub-Station at Hebron, but seemed strong enough to be considered a satisfactory commercial product.

Lot No. 2. The char as received contained a large percentage of raw or dried lignite, some of which was in lumps too large to pass the small crusher in the plant. Of a total weight of 4,286 pounds in this lot, 658 pounds over one inch, mostly of uncarbonized lignite, was screened out and discarded as unfit for crushing and briquetting.

In the crushing of the raw or imperfectly carbonized material, there is a tendency to break into relatively large thin plates to which the binder does not adhere properly. These plates, in the pressing of the mix, tend to arrange themselves with their long axes in planes parallel to the common tangent of the press rolls; and the result is a corresponding tendency for the briquettes to split when leaving the press. Raw or partly dried coal crushed in smooth rolls is compacted into plates of finely divided material weakly bound together by pressure. Although these plates break up in part in the mixers, relatively large lumps hold together throughout and form weak spots in the briquettes. When these spots are at or near the surface of the briquette, they break down on weathering leaving a rough surface much less resistant to abrasion and weathering.

On December 3 and 4, briquettes were made from a mixture having the following proportions by weight:—

*Char (moist)	3,618 lbs.	79.33%
Coking coal	335 lbs.	7.25%
Flour	83 lbs.	1.75%
Coal tar pitch	534 lbs.	11.67%
	4,570 lbs.	100.00%

No particular difficulty was found in the briquetting of the material, except that of crushing, so long as sufficient pitch was used to prevent splitting in the briquettes. There was some sticking of the material in the press, due to the tendency to split.

Lot No. 3. This lower volatile char was much harder than the high volatile char of the previous lots. Being free from raw coal, and harder, the crushing rolls produced a more uniform product. The briquettes made had better surfaces, were stronger and required less binder.

On December 24 two lots were made up, one containing coking coal and one with no coking coal. No change in binder was made. On December 25 one lot was made up using all lignite pitch in place of the coal tar pitch. No coking coal was used, the aim being to determine the relative strengths of the coke formed from lignite pitch, and from coal tar pitch, in the briquette, when in the fire.

The briquettes made on the 24th were the strongest made during the series of tests, having fairly smooth surfaces, and being pressed harder. The briquettes made with

*Analysis of this char is given in the tables Fig. 47.

the lignite pitch binder had smoother surfaces but were not so strong as those made with coal tar pitch, though more binder was used. It was not the intention to use more of the lignite pitch than of coal tar pitch in the runs of the 24th, but with the same setting of the pitch pump, more lignite pitch was fed, probably because of its greater fluidity at the temperature used.

Briquettes containing lignite pitch have less tendency to throw off dust in handling than those made with coal tar pitch alone probably due to the presence of oil in the lignite pitch.

No drop tests were made on these small lots of briquettes produced at the School of Mines, Grand Forks, on account of the lack of uniformity in the product, differences in plant conditions, and further because the results of drop tests with the much larger briquettes used in these tests could not be compared with those of the smaller briquettes made at the Sub-Station at Hebron, North Dakota.

Burning Tests.

The details of the burning tests are shown in the table Fig. 48. With the exception of the high volatile briquettes burned in stove test No. 9, all the briquettes held their shape and maintained a fair strength in the fire, although those containing a small per cent of coking coal were, as would be expected, slightly stronger than the briquettes without the coking coal. On account of the coarser material in, and insufficient pressure on the briquettes there was a greater surface disintegration in the fire than from the smaller, denser briquettes, made at Hebron from the same material (even though the large briquettes contained coking coal and the smaller ones did not). Those made from the low volatile char were better physically and stronger in the fire than the higher volatile briquettes.

The high volatile briquettes broke down badly on heating, the breakage being especially noticeable at the lower or discharge end of the magazine where the relatively low heat, acting on the briquettes in the magazine softened the pitch without obtaining the benefit of the coking qualities of the briquette and allowed the expanding particles of the partly carbonized lignite, high in gas, to loosen and weaken the briquettes. Briquettes charged into the firepot below the magazine at the start held together fairly well so long as they were not disturbed but broke as soon as touched.

The briquettes made with all lignite pitch and flour binder were denser than any of the other lots, apparently due to a higher content of a more fluid pitch. In the stove test ignition was slower but a high maximum temperature was reached with a falling off in temperature more rapid than in the tests of the other briquettes. The briquettes held their shape and maintained a good strength throughout, though no soft coal was used. On account of the decreased strength of briquettes made with an all lignite pitch binder, it is probable that the best results will be obtained by mixing with coal tar pitch.

Results of the burning tests are not altogether comparable with those previously reported for briquettes made from similar material at Hebron, largely because of differences in size and structure of the briquettes. The coarser material in the larger briquettes tends to increase the combustion *rate*: the larger size of briquette reduces the weight of fuel in the firepot and as the briquettes do not spread out properly from the magazine discharge, there is a reduction in the total amount of heat given off per unit of time. With the larger size briquette the ash drops through the fuel bed and grate more readily, tending to maintain the combustion rate more uniformly throughout the burning period. With the smaller briquettes the tendency is to produce a high temperature during the earlier period due to the presence of a larger body of relatively high volatile fuel in which the ash concentration is low. After the volatile is burned off from the fuel in the firepot the ash concentration increases, slowing down the combustion rate. For fuels of approximately the same composition and heat value there is a tendency for the smaller briquettes to cause a higher temperature during the early part of the test followed by a more rapid drop after the maximum has been reached.

While the single stove test of the high volatile briquettes, under the conditions as explained above, appeared to indicate a high heat production it is not probable that more extended tests would show this. Furthermore other conditions affecting cost of production, physical condition, weathering qualities, actual sustained heat value, and ability to stand up under severe firing conditions, make it evident that the very high volatile briquettes will not prove as satisfactory as the lower volatile briquettes, and it seems very doubtful if the production of very high volatile briquettes would prove advantageous to either producer or consumer.

Diagrams of the curves of available heat, room temperatures, and flue gas temperatures for each of the various stove or heating tests are shown in Fig. 49, *a to l* inclusive.

In conclusion the Board wishes to express its indebtedness to Dean E. J. Babcock and Mr. R. L. Sutherland, under whose supervision these tests were carried out.

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APPENDIX 32

Report on Low Temperature Projects in America

CHARLES V. MCINTIRE
Engineer
66 Broadway, New York.

January 11, 1924.

Mr. LESSLIE R. THOMSON, *Secretary*,
Lignite Utilization Board,
288 St. James Street,
Montreal, Canada.

Dear Sir:—

Complying with the request in your letter of the 21st of December, 1923, I have compiled from data in my possession and from my own personal knowledge the following list enumerating the many projects and industries of the United States which have during the last fifteen years been engaged in the development of processes intended for the distillation of coal at low temperatures or for the improvement of certain low grade fuels by distillation methods. This does not take into consideration those processes, such as the high temperature coke oven, the gas retort, or the internally heated complete gasification processes, which have as their objects the manufacture of metallurgical coke from high grade coal or the manufacture of gas.

These projects are listed below:—

- Carbocoal process.
- Piron process.
- Greene-Laucks process.
- University of North Dakota development.
- Wallace process.
- Bussey process.
- Summers oven.
- Sterling Midland Coal Company.
- Jones and Laughlin process.
- Pritchard process.
- Bostoph process.
- Traer process.
- Pennsylvania Coal & Coke Company experiments.
- Brown process.
- Frank process.
- Parr research.
- Johns process.
- International Combustion Engineering Corporation.
- Consolidation Coal Products Company.

THE CARBOCOAL PROCESS

The Carbocoal process, the invention of Mr. Charles Howard Smith, was developed during the years 1914 to 1918 by a group of foreigners headed by Blair & Company of 24 Broad Street, New York. A company known as the International Coal Products Corporation with offices in New York was organized to carry on the development program; a subsidiary company, the Clinchfield Carbocoal Corporation, was organized to operate the first (and only) commercial plant of the process, at South Clinchfield, Virginia.

This widely known development has been carried out on a most extensive scale and is by far the largest of its kind on the American continent, comparing in magnitude with the Coalite development in England.

The process consists of a method of improving the physical properties of coal by three stages of treatment, first, distilling the coal at low temperatures in a stationary retort with internal agitation and recovering the by-products; second, cooling, grinding and briquetting the semi-coke residue with a pitch binder; third, distilling the briquettes at high temperatures in a stationary retort with recovery of by-products. The product, known as carbocoal, is an excellent domestic fuel, comparing favorably with anthracite, and during the development period at Irvington, N. J., and the commercial operation period at Clinchfield, it was well received by the purchasing public.

The primary purpose of the interests who backed the carbocoal project was to find a process for making low grade coals desirable for domestic fuel and fit for any use where high grade fuel is required. They hoped to widen the markets for bituminous coal and thereby create a greater market for certain coals owned by them in large coal bearing areas of western Virginia.

Practically all the development was carried out at Irvington, N. J. in a small semi-commercial plant built chiefly for experimental purposes, at a cost of over one million dollars. Each stage of the process was studied and experimented with over a period of four or five years. Low temperature carbonization retorts of various types and sizes were built and operated, one after another, in an effort to find one which would produce the desired results. Briquetting systems, at least three types of secondary carbonization systems, various systems of conveying and crushing coke and by-product recovery plants were built.

Consulting engineers and designers were retained to assist with the development, among them the well-known consultants: Ford, Bacon and Davis of New York and the engineering firm of Didier-March; the latter were engaged in the design of fire brick settings and other furnace work.

As a war measure, to insure a large production of toluol and other coal by-products needed in warfare, the United States government assisted financially in the building of a commercial carbocoal plant at South Clinchfield.

The plant was finished in 1920 and was operated over a period of about two years. It was rated at a capacity of 500 tons of coal but in operation never exceeded 300 tons of coal and, in my opinion, the average output should be taken at 200 to 250 tons of coal per day. The reason for this disappointingly low capacity was faulty design of apparatus and lack of knowledge on the part of the designers of the actual problems which needed to be solved. Many attempts involving large expenditures were made to improve the Clinchfield plant and to increase its output and reduce its cost of operation but without success and in 1922 the plant was closed down. It still remains idle.

While the plant was in operation the experimental work was kept up at Irvington; a new retort was built which promised to outperform those which had been installed at Clinchfield but whether this promise can be realized has not been demonstrated commercially.

The entire program of the International Coal Products Corporation, in the development of the Carbocoal process and the attempt at commercializing it, is said to have cost upwards of $6,000,000.

THE PIRON — CARACRISTI PROCESS

This low temperature distillation system, recently taken up by the Ford Motor Company, has just enjoyed a great deal of nation wide newspaper publicity under the caption "Ford to burn coal twice." It is the invention of Emil Piron and was first built by him under the financial backing of a local coal operator at Huntingdon, W. Va. This plant consisted of one retort, of relatively small dimensions; in which coal is distilled in a thin layer on the upper strand of a metal conveyor as the conveyor passes or floats over the surface of a molten lead bath. The product is a soft friable semi-coke suitable for domestic purposes only after briquetting or for steam purposes after pulverizing (or briquetting).

The Ford Motor Company, through V. Z. Caracristi has obtained rights to build a plant rated at 400 tons of coal per day at the factory in Ford, Ontario. The plant is said to be under construction and it is said that the cost will be about $400,000. In my opinion the cost of the development plant at Huntington was at least $75,000.

Data derived from my own experiments with apparatus similar to that used by Piron in his original research differs widely from Piron's data as to time required for distillation and the quantity of by-products to be derived from coal. This leads me to believe that the fundamental principle of the Piron design is unsound. I do not believe the process will prove a commercial success.

THE GREENE-LAUCKS PROCESS

This process, developed in Denver, Colorado, by the Denver Coal By-Products Company with offices in New York and Denver, comprises a method of manufacturing a smokeless high volatile domestic coke from bituminous coal in one stage of distillation.

The distillation is carried on in a vertical metal tube which has an internal screw for propelling the coa upward continuously while it is under treatment; both the tube and screw are heated by the gas. By-products are recovered in the usual manner.

The plant at Denver which was first built in 1917 is of commercial proportions. It has been operated from time to time since the start but has never been successful from a financial standpoint. Various interests have investigated the plant with the view of taking over the process, among them the Combustion Engineering Corporation of New York.

I have not seen the Denver plant, but from the information at hand I have formed the opinion it will not be a success, and that the process is not fully developed. Judging from reports and illustrations of the plant I should estimate the total cost of development and building at $500,000.

THE UNIVERSITY OF NORTH DAKOTA DEVELOPMENT

The state of North Dakota through its University has been engaged for the last 12 years in an effort to find a successful method of improving the physical and thermal qualities of North Dakota lignite. Experiments have been carried out at the University laboratories and at a large scale experimental plant at Hebron under the direction of Dean Babcock and much data of value to the scientific world but no process of commercial value has been developed.

The Hebron plant consists of several large substantial buildings for housing the retorting and briquetting apparatus and the laboratories. Many types and sizes of retorts have been tried during the course of the experiments, including a large unit comprising 12 inclined continuous ovens which has been operated over several periods of one to four months each. The system for manufacturing briquettes from the lignite char has functioned satisfactorily.

In addition to the large scale experiments at Hebron, Dean Babcock has continued his research work at the Grand Forks laboratories. A special type of internally heated retort, designed by Mr. Hood of the United States Bureau of Mines, has been built at the joint expense of the University and the Bureau. It has been operated with some degree of success but has not as yet been commercialized.

I have seen the experimental plant at Hebron and I should estimate the cost of construction of this unit, together with the cost of this and other research work, at about $100,000.

THE WALLACE PROCESS

The Wallace process consists of a method of manufacturing coke from bituminous coal in a vertical retort. Coal is distilled between the retort walls and the walls of an inner core of metal by heat transmitted through the former. The coke residue is said to resemble the product of a high temperature furnace while the liquid by-products are of the same high quality as those obtained from ow temperature distillation processes.

The first development work was done by Mr. Wallace in a small plant in East St. Louis. In 1921 a plant consisting of six ovens was built at Petersburg, Va., by the American Gas Company and the Gas Machinery Company at Cleveland, and operated by them in connection with a town gas plant. It has been reported that the original installation was not successful; that numerous changes have been made in the

ovens and that an entirely new oven, known as the Petersburg process, has been developed. It is said that the oven is to be built at Petersburg and that it will be operated on a commercial scale by the Economical Carbonization Company.

I have seen the Petersburg plant and I should estimate that the expenditures for development of the process (which is not yet a commercial success) have exceeded $250,000.

THE BUSSEY PROCESS

The Bussey process, the invention of Charles C. Bussey, has been built at two experimental plants, one a small scale test unit erected in Brooklyn, N. Y., the other unit at Louisville, Kentucky is a larger one.

The Louisville plant consists of one Bussey furnace, which is somewhat similar in design to a gas producer; a coal handling system, and the usual by-products recovery equipment. It was intended to operate on a commercial scale in the processing of Kentucky cannel coal; the gas was to have been sold to a large user in the neighbourhood; and the coke residue was to have been sold on the open market.

Through some lack of capital or other reason, the plant's operating period was brief. It was closed down in 1920 and has remained closed since, with the exception of several short periods when it was put into commission for the purpose of making demonstrations to prospective purchasers of the process.

It is said that the Bussey Process Company, which owns the process, has received financial assistance from time to time from a number of interests and that the total expenditures for construction of the Brooklyn demonstration unit, the construction and operating of the Louisville plant, and the promotion of the process has amounted to at least $200,000.

THE SUMMERS COKE OVEN

The Summers process consists of a long, narrow oven chamber heated from the sides and top by combustion of gases. It is equipped with a moving floor which traverses the entire length of the oven and moves alternately forward and backward by the action of a liquid motor. Coal charged into the oven at one end travels continuously through the heated chamber upon the reciprocating floor and is there converted into coke while being heated and compressed. Three ovens of this type with a total capacity of about 10 tons of coal per day were erected in Harrisburg, Illinois, in 1910, and have operated over several periods, but not continuously and are idle at the present time. The installation is not considered a commercial success. In my opinion, its cost for construction and operating was at least $75,000.

THE STERLING-MIDLAND COAL COMPANY

In 1921 the Sterling Midland Coal Company of Chicago, Illinois, owners and operators of Indiana coal, built a one unit experimental or demonstration plant for distillation of coal at low temperatures at Hammond Ind. The process, known as the Richards and Pringle process, was one previously designed and built in England. The plant consisted of one retort with coal handling system, a by-product house and a laboratory. The retort was a long, narrow oven in which coal travelled through a distilling zone on the upper strand of a continuous metal conveyor and the product was a soft semi-coke of high volatile content which was intended for sale as domestic fuel without further processing.

A short period of operation showed that the plant would not function as intended without being remodeled. It was closed down.

I have seen the plant at Hammond and from my own experience with such construction and operation, I should estimate the capital expenditure to have been about $120,000.

JONES AND LAUGHLIN EXPERIMENTS

Since the year 1920 the blast furnace department of the Jones and Laughlin Steel Company of Pittsburgh has been engaged in more or less continuous experiments in low temperature carbonization of Pittsburgh coal. The primary object of this research is to improve the physical structure of the metallurgical coke manufactured in the steel works coke ovens by the admixture, with the high volatile gas coal, of a certain percentage of pulverized soft coke of 15 to 18 percent volatile content. Of course the main difficulty in this program lay in the development of a suitable piece of apparatus for producing the semi-coke at low temperatures; and at least two types of retorts have been built and tested. One of them, which was in operation in 1921, consisted of a revolving drum heated externally after the manner of the Thyssen process.

I have seen this experimental plant and should estimate the cost of construction, maintainance and operation at from $50,000 to $75,000.

PRITCHARD PROCESS

The Pritchard process, developed by Thomas W. Pritchard is owned by the Acme Coal Products Corporation of New York, a corporation capitalized at $1,000,000.

The process consists of a method of retorting coal within a metal muffle by means of heat transmitted through the walls and also by heat carried into the retort by hot gases recirculated from the bottom. Small scale test units were built at Hoboken and operated intermittently but not on a commercial scale. Tests have also been conducted in a bone distillation plant at Allentown, Pa. No commercial units have been installed although the owning company has made efforts to promote the process as a system for manufacturing gas for city use.

I have seen the Hoboken plant and have formed the opinion that the process is not yet in commercial shape and that the expenditures for construction and development work amounted to an least $30,000.

THE BOSTOPH PROCESS

The Bostoph process was one of the early attempts at low temperature carbonization for the purpose of manufacturing a smokeless domestic fuel from bituminous coal. It was built in an experimental plant at Warsaw, Indiana, and operated for a short time but was finally abandoned as impractical. I have no information as to the size or cost of this installation.

THE TRAER PROCESS

This system consisted of a method of manufacturing domestic coke from bituminous coal in which coal was loaded into small vertical metal containers and passed through a long horizontal tunnel heated externally by gas. An experimental or demonstration plant is said to have been built in Chicago in 1917 and abandoned after a short series of tests. It is not considered a feasible commercial process.

PENNSYLVANIA COAL AND COKE COMPANY

Pennsylvania Coal and Coke Company, 17 Battery Place, New York, operators of Pennsylvania coal, financed an experimental undertaking in low temperature carbonization several years ago. A small plant was built at Cresson, Pa. which plant consisted of one retort unit of the revolving drum type. It was operated for a very short period and then abandoned because it did not appear to possess commercial possibilities. Judging from reports at hand, I should say the total expenditures for this unit were at least $50,000.

THE BROWN PROCESS

This system is owned by the Shale Oil Machinery and Supply Company, 342 Madison Avenue, New York. The retort consists of three units of the revolving drum type set end to end heated externally. The material to be heated passes through the three drums in series.

The process has been developed primarily for the distillation of shale but is said by the owners to be suitable also for coal and lignite. No commercial plants have as yet been built so the process must be considered as still in the experimental stage. It is claimed that the development expenses amounted to $50,000 to $100,000.

THE FRANK PROCESS

The Frank process, owned by Thermo-Catalysis Inc. of San Francisco, is a system of distilling coal in a retort which is heated internally by direct combustion of gases therein. A small experimental plant, probably of laboratory size, has been built and operated in California, but no reports are available to indicate the probable cost or success attained.

THE PARR PROCESS

Professor Parr of the University of Illinois has interested himself in the matter of low temperature distillation of coal for many years. He has conducted numerous experiments on a laboratory scale at the University and has produced much of interest to scientists and investigators although his efforts have not resulted in a process which could be applied commercially.

JOHNS PROCESS

This process is now owned by the Industrial By-Products Company, 25 Broadway, New York, and is offered by them as a method of distilling coal, lignite or oil shale. It is said to have been developed in an experimental plant at Denver, Colorado. The retort consists of a long, narrow chamber set at a slight incline with the horizontal, the floor of which is heated by gas flames; lignite enters the upper end of the floor and is propelled along it by the action of a series of metal paddles which swing backward and forward.

According to a prospectus issued to investors, a new company, The Empire Fuel Products Corporation, has been organized for the purpose of building and operating an experimental and a commercial plant of this system at Rockdale, Texas with the object of perfecting and commercializing the process. It is my opinion that the process is still in the experimental stage and that, if the new company carries out its development program, it will be obliged to spend at least $150,000 before it can learn whether the process is or is not of commercial value.

INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

The International Combustion Engineering Corporation, 43 Broad Street, New York, have during the last four or five years investigated many low temperature distillation processes, among them the Greene-Laucks process of Denver. Recently the corporation has retained a consulting chemist of New York to investigate a German process with the view of conducting experiments in this country. This is mentioned to show the general interest in the subject; but, since no plants have been built and all of the expenditures by this organization have been for investigations, I have no means of judging their total outlay.

CONSOLIDATION COAL PRODUCTS COMPANY

The Consolidation Coal Products Company, financed by the Consolidation Coal Company of 67 Wall Street, New York, has recently been organized to conduct experiments in low temperature carbonization of coal with the object of producing a smokeless domestic fuel from high volatile bituminous coal. An experimental plant costing over $100,000.00 has been built at Fairmont, West Virginia, and tests have been made; but as yet the results of the experiments have not been published. I have been retained by Messrs. Coverdale and Colpitts, the Consulting Engineers who represent the Consolidation Coal Company, in active charge of this experimental work.

The projects briefly described in the foregoing paragraphs may be summarized as follows ;

Investigation or research work, no plant	2
Experimental plants — no commercial undertaking	13
Experimental and commercial, or semi-commercial plants which were unsuccessful commercially	4
Successful commercial plants	none
Total	19

I have no means of determining the amounts of capital expended to carry on these various experiments and enterprises, but for the purpose of this report I have set down a rough estimate, or opinion, as to the probable cost of some of the important ones. These figures are based on my knowledge of costs for similar enterprises but aside from that they have no value. The various projects may be summarized as to cost as follows :

Carbocoal	$6,000,000.
Piron	475,000.
Greene-Laucks	500,000.
University of North Dakota	100,000.
Wallace	250,000.
Bussey	200,000.
Summers	75,000.
Sterling-Midland Coal	120,000.
Jones and Laughlin Steel	75,000.
Pritchard	30,000.
Pennsylvania Coal and Coke	50,000.
Brown	50,000.
Johns	100,000.
Consolidation Coal Products Company	100,000.
Total cost — my estimate	$8,125,000.

Any error that may be in the above summary is probably on the small side. Total expenditures for the development of low temperature distillation in the United States has probably cost a great deal more than the figure set down in the preceding, and yet all this money and time has not accomplished the desired result — a commercially successful plant. It has produced a vast amount of infinitely valuable information concerning the art of distillation of coal which may be and undoubtedly will be applied to advantage by those who still continue in the business.

Very truly yours,

(*Sgd.*) C. V. McINTIRE.

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APPENDIX No. 33

Appendix No. 33 will be found after p. 263.

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APPENDIX No. 34

Professional Records of Members of Staff.

LESSLIE R. THOMSON

EDUCATION AND TECHNICAL QUALIFICATIONS.

Educated Upper Canada College, Toronto, 1900-02, and the University of Toronto, as follows:—

Graduated Mechanical and Elect. Engineering	1905
Degree of B.A. Sc., (Hydraulics and Strength of Materials.)	1906
Graduated in Civil Engineering	1907

TRAINING AND EXPERIENCE

Seasons of 1905, 1906 and 1907 acted as assistant engineer to the late Joseph Rielle, Montreal, on general office work, administration, field work, and construction. Lecturer in Civil Engineering, University of Manitoba, Winnipeg, 1910 to 1912. 1912 to April, 1918, continuously with the Dominion Bridge Company Limited, in the following capacities: detailer, checker, designer and resident engineer. During this period prepared designs for all types of buildings, power houses, highway bridges, railway bridges, viaducts, abutments, etc. In addition was given responsible charge of certain special work, involving combinations of hydraulic, mechanical and structural engineering, as for example, the large caissons of the new dry dock at Levis, P. Q. and the design of the Stoney Sluice Gates at LaSalle Street, Montreal.

During 1917 and 1918, was in responsible charge of the installation of all the steel work for the new Parliament Buildings, Ottawa, under the direction of John A. Pearson, Architect.

April, 1918 to October, 1918, was Secretary of the Honorary Advisorary Council for Scientific and Industrial Research, Ottawa.

October, 1918, to date, Secretary of the Lignite Utilization Board, Montreal.

1920 to date, Special Lecturer in Structural Engineering, McGill University, Montreal.

TECHNICAL SOCIETIES AND PAPERS

Member, Engineering Institute of Canada.

Member of the American Society of Civil Engineers.

"The Rolling and Floating Caissons of the Levis Dry Dock" Pres't. to Eng. Inst. Canada	1915
"Transmission Lines, Poles, and Towers" Presented to the Engineering Institute of Canada	1916
"The Briquetting of Lignites" Presented to Society of Chemical Industry	1921

EDGAR STANSFIELD

EDUCATION AND TECHNICAL QUALIFICATIONS.

Honor School of Chemistry, Victoria University, Manchester, B. Sc. .. 1900
Honor School of Chemistry, Victoria University, Manchester, M. Sc.. 1903

TRAINING AND EXPERIENCE

Assistant Lecturer and Demonstrator in Chemistry at the Sunderland Technical College 1901 — 1906. Assistant Chemist at the Dominion Iron and Steel Company, Sydney N. S. 1906 – 1907. Chief Chemist for an investigation of Canadian coals conducted at McGill University, Montreal for the Dominion Government, 1907-1910. Chief Engineering Chemist, Fuel Testing Division of the Mines Branch, Department of Mines of Canada, Ottawa, Ont. 1910-1918. Chemical Engineer to the Lignite Utilization Board, 1918-1921.

Fuel Engineer, Scientific and Industrial Research Council Province of Alberta, 1921 to date.

PROFESSIONAL CONNECTIONS AND PAPERS.

Fellow of the Chemical Society, (London).
Member of the Faraday Society.
Member of the Canadian Mining Institute.
Member of the Engineering Institute of Canada.
Author or part author of the following papers:—

"Preliminary Note on the Preparation of Barium", Memoirs and Proceedings of the Manchester Literary & Philosophical Society, Vol. XLVI (1901), No. 4. "Spontaneous Combustion of Coal", Canadian Mining Institute, 1910. "Two Simple Forms of Gas Pressure Regulator" Faraday Society, 1911. "An Investigation of the Coals of Canada" Mines Branch Report No. 83, Vol. 1, Parts III & VI, Vol. II, Part IX and Vol. VI, 1912. "Products and By-Products of Coal", Mines Branch Report No. 323, 1916. "The Carbonization of Lignites", Royal Society of Canada, 1917. "The Carbonization of Lignites" Part II, Royal Society of Canada, 1918. "Analyses of Canadian Fuels", a compilation in five volumes, Mines Branch Reports No. 479 — 483, 1918. "Low Temperature Carbonization of Fuels", Canadian Society of Civil Engineers, 1918. Also the following from Mines Branch Summary report: "Report on Tests on Blaugas", 1910. "The Determination of Moisture in Fuels", 1911. "Report of Tests on Pyrene", 1911. "An Electrically Heated Tube Furnace", 1911. "An Electrically Heated Tar Still", 1912. "Specifications for the Purchase of Oil", 1911. "Lignite Carbonization", 1919. "Carbonization of Canadian Lignite" Journal Industrial and Engineering Chemistry, Jan. 1921.

R. DeL. FRENCH

EDUCATION AND TECHNICAL QUALIFICATIONS

Graduated Worcester Polytechnic Institute, Worcester, Mass., B.Sc... 1905
Graduated Worcester Polytechnic Institute, Worcester, Mass., in Civil Engineering... 1906

TRAINING AND EXPERIENCE

Draftsman, Assistant Engineer, Division engineer and principal assistant-engineer in charge of design of sewage system, City of Louisville, Ky. 1908-1910. Assistant and Acting Chief Engineer, National Concrete Construction Co. Louisville, Ky., on design and construction of re-inforced concrete buildings, bridges, reservoirs, etc., and concrete pile driving (Simplex system), 1910-1911. Principal Assistant Engineer, R. S. & W. S. Lea, Consulting Engineers, Montreal on municipal work, including sewers and water systems, filtration plants, sewage disposal plants, pumping and power stations, hydraulic development and legal work, 1911-1918. Partner, Arthur Surveyer & Co., Consulting Engineers, Montreal 1918-1919. Engineer, Lignite Utilization Board, 1918-1921. Instructor in Sanitary and Municipal Engineering in Faculty of Applied Science, McGill University, 1911-1921. Professor of Municipal and Highway Engineering, McGill University, 1921 to present date.

PROFESSIONAL CONNECTIONS AND PAPERS

Member, Engineering Institute of Canada, Associate member, American Society of Civil Engineers. Member, Board of Examiners, Engineering Institute of Canada. Awarded Gzowski Medal by Eng. Inst. of Can. for paper entitled:

"Covered Suction Reservoirs" presented to Engineering Institute of Canada 1918.

H. JOHNSON

EDUCATION AND TECHNICAL QUALIFICATIONS

Graduated McGill University, B. Sc., in Civil Engineering 1915

TRAINING AND EXPERIENCE

Construction work steel and reinforced concrete buildings and highway bridges, McKinnon-Holmes, Sherbrooke, Que., summers of 1913 and 1914. Lieutenant, C. E. F. Field Artillery, 1916-1918. Promoted to Captain 1918. Transferred to Royal Air Force in 1918 — 3 years' service in France — Demobilized 1919. Assistant Engineer, Lignite Utilization Board, Montreal 1919 - 1921. Transferred to Lignite Utilization Board's plant at Bienfait 1921-1922. Severed connections with Board in 1922.

PROFESSIONAL CONNECTIONS

Associate Member, Engineering Institute of Canada, 1921.

R. A. STRONG

EDUCATIONAL AND TECHNICAL QUALIFICATIONS

Graduated University of Illinois, Urbana, Ill., B. A., 1915, B. Sc...... 1915

TRAINING AND EXPERIENCE

Field work, Illinois coal mines, 1915. Assistant Chemist and Metallurgist for Dominion Bridge Company, Lachine, P. Q. 1915-1918. Lieutenant Canadian Engineers C.E.F. 1918-1919. Assistant foreman of Copper Refinery Dominion Copper Products, Lachine, P. Q. six months in 1919. Assistant Chemist, Lignite Utilization Board, 1919-1920, Acting Chemical Engineer, Lignite Utilization Board 1920-1921, Chemical Engineer, Lignite Utilization Board at Bienfait, Sask. 1921 to date.

PROFESSIONAL CONNECTIONS

Associate Member, Engineering Institute of Canada — Member of Canadian Institute of Mining and Metallurgy — 1921.

I. F. ROCHE

EDUCATION AND TECHNICAL QUALIFICATIONS

Graduated McGill University, B Sc., in Civil Engineering............. 1913

TRAINING AND EXPERIENCE

Assistant to Superintendent of Construction, John S. Metcalf Co. Trenton, Ont. 1913-1914. Resident Engineer, Canadian Light & Power Co. St. Timothee, Que. 1914-1916. Test Engineer, Imperial Munitions Board, Montreal, Que. 1916-1917, Assistant Engineer, Fraser Brace & Co. Montreal, Que. Construction of wooden ships and LaSalle Bridge, 1917-1919. Assistant Engineer, Lignite Utilization Board, Montreal, Que. 1919. Resident Engineer on construction of plant at Bienfait, Sask., Lignite Utilization Board 1920-1921. Resident Manager, Lignite Utilization Board, Bienfait, Sask. 1921 to date.

TECHNICAL SOCIETIES

Associate Member, Engineering Institute of Canada, 1920. Member, Canadian Institute of Mining and Metallurgy.

W. G. HEPTINSTALL

EDUCATION AND TECHNICAL QUALIFICATIONS

Norton Grammar School.. 1901
Two years University of London.................................. 1903

TRAINING AND EXPERIENCE

British Admiralty 2 years in charge of engine room 1915-1917. In charge of repair shop, British Admiralty 1917-1919. Operated electric light plant, Town of Minnedosa, Man. 1919. Operated light and power plant, Town of Yorkton, Sask. 1920. Mechanical Superintendent at Bienfait, Sask., for Lignite Utilization Board plant from 1920 to date.

TECHNICAL SOCIETIES

Member of American Society of Mechanical Engineers............... 1921
Member of Canadian Institute of Mining and Metallurgy............. 1921

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APPENDIX No. 35

Lignite Utilization Board of Canada

To those who may become interested in a business way in the activities of the Lignite Utilization Board of Canada the following information is addressed:

CONSTITUTION — The Board is created by an Order-in-Council of the Dominion of Canada supplemented by an agreement as to finances with the Provincial Governments of Manitoba and Saskatchewan, by which the three governments have appropriated $400,000 for the use of the Board.

BUSINESS STATUS — In its relation towards business interests, the Board has the powers of an incorporated company to buy, sell, make contracts, hold property, etc. In its relation to the Government, it is a trust, holding and expending funds provided by the governments, and having power to hold property in trust.

REASON FOR CREATION OF BOARD — The citation of part of the Order-in-Council will give clearly the reasons for the creation of the Board:

"That there are large deposits of lignite underlying various districts of the Provinces of Saskatchewan and Alberta, some of which, in the raw state can only be utilized when freshly mined, and are, moreover, unsuited in such state to household use;"

"That by carbonizing this lignite, a coke or charcoal is obtained which briquettes readily and, without consideration of the by-products such as oil, pitch, ammonia sulphate, gas, etc., the result is to turn two tons of inferior fuel into one ton of briquettes approximating, in heating value, anthracite coal with practically the same heating value in the domestic furnace as the two tons from which it was made;"

IMMEDIATE OBJECTIVE — The immediate objective of the Board is the carbonizing and briquetting of the lignites of southern Saskatchewan for domestic use.

PROGRAMME — To reach this objective the following will be the steps undertaken:

(*a*) A thorough investigation will be made of all machines and processes in use on this continent covering carbonization of coal, the use of binders, and briquetting.

(*b*) With full information at hand regarding machinery and processes, the Board will construct or contract for a plant of commercial size adjacent to the developed mines of southern Saskatchewan.

(*c*) After operations are developed to a point where a commercial product may be obtained, the Board will distribute its output through the ordinary channels of trade.

(*d*) While the production of domestic fuel is the immediate objective, the by-products derived therefrom will be studied, as will also the use of carbonized or powdered fuel for commercial power purposes.

NOTES — It is proposed that the capacity of the carbonizing and briquetting plant shall be not less than ten tons per hour.

Western Canada has heretofore imported about 500,000 tons of anthracite from Pennsylvania at a cost of about $5,000,000 per annum.

Canada's coal resources are greater than those of any country in the world, with the exception of the United States. Much of Canada's coal, however, requires treatment before being available for satisfactory domestic use.

It is expected that a successful outcome of the development undertaken by the Board will result in the establishment of an industry of national importance.

PERSONNEL — The personnel of the Board appointed by Order-in-Council of the Dominion Government is as follows:

R. A. Ross, Consulting Engineer, Montreal, *Chairman*
The Honorable J. A. SHEPPARD, Moose Jaw, Sask.
J. M. LEAMY, Provincial Electrical Engineer
of the Government of Manitoba, Winnipeg.

STAFF — The Board has appointed the following staff:

LESSLIE R. THOMSON, A.M.E.I.C., Secretary.
EDGAR STANSFIELD, M.E.I.C., Chemical Engineer.
R. DEL. FRENCH, M.E.I.C., Engineer.

ADDRESS — For the immediate present, work will be carried on in Montreal at the address given below, but thereafter it is anticipated that headquarters will be established at some point in the western provinces of Canada.

Address all correspondence to Lesslie R. Thomson, Secretary, Lignite Utilization Board, 80 St. Francois Xavier Street, Montreal.

R. A. Ross,
Chairman.

MONTREAL, *October 1st, 1918.*

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APPENDIX No. 36

Report on Domestic Fuel Situation in Canadian West

MONTREAL, *February 8, 1919.*

THE LIGNITE UTILIZATION BOARD OF CANADA,
80, St. Francois Xavier St.,
Montreal.

Gentlemen:—

Acting under your instructions, I proceeded to Winnipeg, Regina and Fort William for the purpose of investigating domestic fuel conditions in the Provinces of Manitoba and Saskatchewan, particularly as regards the present and future use of Western Canadian coals. January 27th, 28th and 29th and February 1st, 2nd and 3rd were spent in Winnipeg, January 30th and 31st in Regina and February 4th in Fort William.

In addition to information which I was able to gather from personal interviews with those who might be expected to have valuable opinions on the fuel situation, I arranged with Mr. J. A. Macdonald, Fuel Administrator for Manitoba and with Mr. Thomas M. Molloy, Fuel Administrator for Saskatchewan, to secure for me by means of questionnaires, opinions on the points at issue from a selected list of retail dealers in these two provinces.

In Winnipeg, I met and conversed with about forty gentlemen, approximately half of whom were members of The Engineering Institute of Canada. It is obviously unnecessary to give here each person's remark in detail, but my opinion, based upon these remarks, is briefly summed up in the following paragraphs:—

(1) Western coal owes its extensive use this season to the efforts made by the Fuel Administration early last summer. This Administration at first warned the consumers that in all probability they could secure only a small portion of their normal supply of American anthracite. Later, the proportion which would be available was set at 50%, then 65%, and during the last few weeks

there has been an abundant supply of American anthracite and no restrictions on its purchase. In fact, there is a considerable amount in storage in Winnipeg, and on the docks at Fort William and Port Arthur, with a comparatively small demand.

(2) The general opinion seems to be that Western Canadian coal has been a fairly satisfactory fuel for domestic use. It is admitted by all that the present winter, an exceptionally mild one, during which there have been only a few days of the very cold and windy weather to be expected in Winnipeg in a normal season, may be responsible to a large extent for the good showing made by this coal.

(3) The objections raised to the use of Western coal in domestic heating apparatus are:—

(*a*) A larger quantity is required than of anthracite to produce the same amount of heat;

(*b*) It is somewhat dirtier, both in handling and in the furnace;

(*c*) It requires more attention;

(*d*) Western coal from some fields slacks to a considerable extent during storage. This adds to the difficulty of handling and of keeping up a proper fire.

(4) It is the general opinion that Western coals will hold in future a considerable part of the market which they have gained this season. This belief is due in part to the efforts of the Western operators to market their product, in part to a belief that the same quantity of heat may be obtained as cheaply from Western fuel as from anthracite, and in part to a legitimate sentimental desire to retain as much of Winnipeg's fuel bill in Canada as is possible.

The opinions of some gentlemen best qualified to discuss the situation are of special interest. Mr. J. A. Macdonald, Fuel Administrator for Manitoba believes that Western coals will hold at least 50% of the market which they have gained. His opinion is based upon information which has come to him in the course of his duties, and is entitled to serious consideration. Mr. W. G. Williams, Manager, Co-operative Supplies Department, United Grain Growers, Ltd., sets this figure at 60% instead of 50% as does Mr. Macdonald. Mr. Williams draws his data from reports from about 100 elevators of his company handling coal, distributed throughout Manitoba. Mr. W. J. Dick, Coal Sellers, Ltd., did not wish to commit himself to a definite figure, but his opinion is very similar to those of Messrs. Macdonald and Williams.

In Regina I met and discussed this matter with about twenty representative citizens, including a number of engineers. The normal situation here is somewhat different from that in Winnipeg. Western soft coal has always been used to a considerable extent in the spring and fall, anthracite being reserved for use during the more severe weather. It is estimated by Mr. Cameron, of the City Coal Company, Ltd., that in normal times approximately 90% of Regina's domestic fuel requirements are supplied from the Western fields, the balance representing the American anthracite used. He does not think that this proportion has been greatly changed during the recent shortage.

The disadvantages of the use of soft coal as expressed by Regina citizens are the same as those held in Winnipeg.

At the present time I am unable to give your Board any definite information as to the feeling in the smaller places throughout Manitoba and Saskatchewan. However, when the results of the questionnaires sent out by the two Fuel Administrators come to hand, this information will be available. In the meantime, I do not see any particular reason why conditions in the smaller places should not be similar to those already described as obtaining in Winnipeg and Regina, bearing in mind the geographical location of the town and its influence on freight rates.

The consumption of Bankhead briquettes both in Winnipeg and Regina has been on a larger scale this season than hitherto. In Winnipeg, 10,000 to 12,000 tons have been sold to date, and at no time has there been more than a small quantity in storage, the market absorbing the briquettes as fast as they were received from the West. In conversation with a number of gentlemen who are using these briquettes, I became convinced that on the whole they were well regarded. The principal objections to them are their smokiness and odor when fired, but it is admitted that these objections may be minimized by the exercise of a little skill.

With two or three exceptions, everyone with whom I came in contact believed that an excellent market existed for a briquette equal in heat value to those from Bankhead, and superior in point of behavior in the fire.

There is no question but that most people in the West began to burn Western coals not from choice but from necessity. Under the extremely mild weather conditions prevailing this season, these fuels have, on the whole, given fair satisfaction, but it is a question if they would be equally satisfactory in severe weather.

At Fort William I had an interview with Mr. Devlin, manager for James Murphy, a large independent importer of American coals. This concern buys American coal outright, imports it from Buffalo, Loraine, Erie, Ashtabula and other lake ports in their own bottoms, and handles it at their own docks at Fort William. The greater part of the American coal imported into Canada through Fort William and Port Arthur is, however, shipped on consignment by the various anthracite mining concerns to the dock companies there. Sales are made entirely by the mining companies, the dock companies receiving merely a fixed charge for handling the coal, and having nothing whatever to do with its disposal.

Mr. Devlin states that the anthracite interests, including his own firm, expect to start a campaign early the coming spring, to regain the business which they have lost this season. He admits that Western coal will probably hold part of the market which it has won, but does not believe that the percentage thus retained will be as large as do the Western operators. He looks for a much better quality of anthracite in the future than that imported during the last two or three years, which has been admittedly badly prepared. He believes that the cleanliness, concentration and general convenience of American anthracite will regain for it to a large extent its place in the esteem of those who formerly used it. He states that, in general, the retail dealer prefers to handle anthracite, since it is not subject to spontaneous combustion, and may be stored in the open with very little deterioration. Western coals, on the other hand, require much more careful treatment.

Judging from the information outlined above, and from the general attitude of those with whom I came in contact during my trip I believe that there is little doubt but that anthracite coal will be permanently replaced to some extent by the Western Canadian coals. It is a difficult matter to give any figures in this connection. Personally, it appears to me that if the anthracite interests make a determined effort to regain their market, the Western operators will be fortunate if they can retain 50% of the market which they have gained this past season.

Quite aside from the general convenience of the two fuels, the matter of price must be considered. It appears to be the general opinion of both hard and soft coal interests that a good quality of anthracite will be available in Winnipeg, for about \$12.00 per ton within a comparatively short period. On this

basis, Western coals would have to sell there for from $6.00 to $9.50 per ton if the relative prices of the two kinds are to remain approximately as they are to-day. These prices for soft coal are believed by some of the Western operators to be too low to allow them a reasonable margin of profit, unless conditions can be modified so as to permit the operation of their mines at approximately full output for twelve months in the year. From confidential information which was given to me by the representative of one of the larger colliery companies, I am able to state that vigourous steps are being taken to reorganize operating conditions along these lines. How far these steps will be successful remains to be seen.

There is no doubt in my mind but that a good market exists for a briquette of the quality which the Board hopes to produce. Assuming for the sake of argument, that the importations of anthracite from the United States are in future only 50% of what they have been in the past, this still leaves a consumption of about 250,000 tons per annum. To make this quantity of briquettes would require about 500,000 tons of raw lignite, which is considerably more than the present output of all the mines in the Souris field.

In conclusion, although conditions as regards domestic fuel have changed greatly in Manitoba and Saskatchewan during the past twelve months, I can see no reason why the Board should not carry out its original programme.

Respectfully submitted,

80, St. Francois Xavier St.,
MONTREAL, *April 30th, 1919.*

(*Sgd.*) R. DEL. FRENCH,
Engineer.

The Lignite Utilization Board of Canada,
80 St. Francois Xavier St.,
Montreal.

Gentlemen:—

On February 8th, 1919, I submitted to you a report covering my observations with regard to the domestic fuel situation in Western Canada, as noted during a two weeks' trip in Manitoba and Saskatchewan.

In that report it was stated that I had arranged with the Fuel Administrators of these two Provinces to circulate certain questionnaires among the retail coal dealers for the Board. The replies to these questionnaires have now come to hand, and the following remarks are based upon the results of an examination of the replies.

The Fuel Administrator for Manitoba circulated 180 questionnaires, of which 133 were returned with the information asked for. The corresponding figures applying to Saskatchewan are 516 and 333.

As nearly as can be ascertained, the population of the Manitoba towns to which questionnaires were sent is approximately 275,000, or about 50% of the population of the Province. In Saskatchewan, about 40% of the urban population is covered by the questionnaires. As a matter of fact, a considerably larger percentage of the total population of each province was probably reached, as it is not possible to estimate what rural population is tributary to the various towns and villages from which replies were received. Personally, I should estimate that in Manitoba the coal dealers circularized supply probably 65% of the population, and that a fair estimate for Saskatchewan would be about 60%.

A copy of the questionnaire itself is attached to this report. Although considerable care was exercised in drawing up all the questions in such a way as to get positive answers, a considerable number of the replies were so worded that it is difficult to ascertain their exact meaning.

A minute analysis of the answers to each of the questions submitted would have given results which I consider would have been of more or less doubtful value. I have, therefore, classified the replies to each question under a comparatively small number of general headings, as may be seen by referring to the following table.

TABLE 1.

Analysis of Replies to Questionnaires, Showing Percentage Responding in the Manner Listed.

	Manitoba	Saskatchewan	Average, weighted in proportion to total number received.
QUESTION I.			
1. Yes, without qualification,	65%	40%	47%
2. Yes, except in base-burners and self-feeders	13	13	13
3. Yes, to a large extent,	3	5	4
4. Yes, to a limited extent only,	5	16	13
5. No, without qualification,	12	25	22
6. No reply, indefinite, etc.,	2	1	1
QUESTION II.			
1. Well satisfied,	28%	14%	18%
2. Fairly satisfactory,	26	27	27
3. Satisfactory, except in severe weather,	16	7	9
4. Satisfactory for cooking, not for heating,	2	2	2
5. Not satisfactory,	28	45	39
6. No reply, indefinite, etc	5	5	5
QUESTION III (See Page 252.)			
QUESTION IV.			
1. More soft coal will be used,	47%	29%	35%
2. Proportion of anthracite sold will be the same as previous to the war,	47	67	61
3. Soft coal will replace wood, but not anthracite,	4	0	1
4. No reply, indefinite, etc.,	2	4	3
QUESTION V.			
1. Price is the dominant factor,	31%	17%	21%
2. Quality, convenience, etc., are the dominant factors,	45	67	61
3. Both price and quality, etc., will be considered	20	10	13
4. No reply, indefinite, etc	4	6	5

It seems to me that certain broad conclusions may be drawn from the figures of the above table although it must be admitted that these data are unrefined.

Considering the replies to Questions I and II, apparently the people of Manitoba were more successful in adapting their existing heating apparatus to the use of Alberta soft coals than were those of Saskatchewan, and possibly more adept in its operation with these fuels. A partial explanation of this difference may be found, perhaps, in the differences between the populations of the two provinces. 56% of Manitoba's population is rural, while nearly 75% of Saskatchewan's population lives outside the cities and towns. Thus, there are undoubtedly proportionately more furnaces, steam boilers, hot water heaters, etc., in Manitoba than in Saskatchewan, where the old fashioned base burner is still the standard heating apparatus for the greater part of the population. Individual replies to this question have ranged from the highest eulogies of soft coal to its absolute condemnation. The majority, however, have apparently been well considered, and I believe that they represent fairly the general opinion of the coal dealers and reflect fairly the opinions of the coal users.

In the replies to Question III, it is apparent that, practically speaking, there are no special devices for the combustion of soft coal which have proved entirely satisfactory. One firm offers a hopper feed attachment for the ordinary furnace or heater, but the few reports as to its use indicate that it is not completely successful. Another firm has developed a magazine feed stove which seems to work well. The general introduction of this device has been hampered by its price, which is referred to as "unreasonably high"

The replies to Question IV are noteworthy, as they indicate a substantial difference in opinion as to the future of soft coal. The dealers in the cities and larger towns are about evenly divided as to whether or not soft coal will be able to hold any substantial portion of the market into which it has been forced during the past season. In the rural districts, on the other hand, the majority of coal users prefer anthracite, and will insist on having it regardless of price, if it is at all procurable. In this connection, it may be noted that there have been numerous complaints against the preparation of Alberta soft coals, one dealer going so far as to state categorically that one-third of his shipments consisted of slate, bone, clay, dirt, etc.

Turning to Question V, it is surprising to see how little weight the price of coal is given. Briefly expressed, the general attitude is that the objections to the use of soft coal, such as its dirtiness, inability to hold fire, excessive attention required, etc., are so great that the majority of users would gladly pay a much higher price for a more uniform, cleaner, and more easily handled fuel.

Although the dealers were not asked to express any opinion regarding briquettes, nevertheless, a number did so. Referring to the "Bankhead" or "Banff" briquettes, the opinions expressed were generally favourable. One dealer emphasized the favourable condition of the market, which led him to believe that prepared lignite briquettes would meet with a warm welcome from the consumer.

I believe that the results obtained from the circulation of this questionnaire bear out the opinions I expressed in my report to you of February 8th, namely, that although soft coal has become a much more important factor in the domestic fuel situation in Manitoba and Saskatchewan during the past season, yet the demand for high-grade fuel is such that this market would easily absorb all the prepared lignite briquettes which are likely to be manufactured during the next few years.

All of which is respectfully submitted.

R. De L. French,
Engineer.

COPY OF QUESTIONNAIRE CIRCULATED IN MANITOBA AND SASKATCHEWAN

1. Is soft coal being generally burned in the same appliances as were formerly used for anthracite?
2. Has the burning of soft coal in these appliances been a success? What has been the general experience of your customers with soft coal as compared with anthracite?
3. Are any special or patented devices for burning soft coal in use among your customers, such as special furnaces, underfeed hopper feeders, etc.? What are they? Have they given satisfaction? If not, how have they failed?
4. Assuming that conditions as to prices and supply of all kinds of coal return approximately to where they were before the war, do you look for soft coal to retain any considerable part of the trade in future? Or do you think consumers will go back to the use of the same proportion of hard coal as previously?
5. What do you consider is the governing condition that would influence consumers to use hard or soft coal? Is it the price or is it the actual burning and heating qualities of the coal?

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APPENDIX 37

Laboratory Experiments on Lignite
Agreed Upon at 3rd Meeting of Lignite Board — Feb. 10th, 1919.

Storage, Etc.

1. — Investigation of the relative weathering and storing qualities of raw, air dried, oven dried and carbonized lignite.

Experiments at Ottawa on absorption and evolution of water; probably completed by March 1. Experiments at Toronto University on Physical and Chemical absorption of oxygen; probably completed 1920.

Important results may be obtained and interim reports may guide commercial development; but latter could safely proceed without waiting for these results.

Carbonization.

2. — *Heat of carbonization.* Determination of the quantity of heat required to complete carbonization at any temperature. Now in progress, probably completed by March 15.

Results essential to good design of retort, also will indicate necessity (or otherwise) for supplementary gas supply. Results will be ready in time for commercial development.

3. — *Rate of carbonization.* Determination of the rate of carbonization of lignite under such varied conditions as in high or low temperature retorts with stationary or moving charges. Work now in progress, and some results already available. Experiments preliminary to erection of shaft retort (see 5) completed by March 1; if the Board decides to proceed with the design of a commercial size of rotary retort, the necessary further work might be completed by June 1.

An experimental rotary retort, complete except as to its heating furnace, is available for the work of 3 and 4 and for carbonizing lignite for briquetting tests.

4. — *Atmosphere during Carbonization.* Investigation of the effect of the presence of steam, lignite gas, furnace gasses, etc., in the retort during carbonization on the product of carbonization. Not now in progress, might be completed by September 1.

Much of this work has its main importance in the provision of data for the scientific "laying of ghosts".

5. — *Stansfield's retort.* Test of small model of suggested high temperature shaft retort. This to be set up out of doors with rough shed cover. Delay start to obtain preliminary patent protection and results of 3.

Probable completion April 1.

BRIQUETTING.

6. — (*a*) Investigation of the relative suitability for briquetting of lignite carbonized at different temperatures.

(*b*) Investigation to determine the best fineness of material to be briquetted.

(*c*) Investigation of the available binders. Eight or nine types of binders have been suggested, but this list could now, or very shortly, be reduced to three or four. It will be necessary, however, to test samples of varying hardness of such binders as oil or coal tar pitch.

(*d*) Investigation as to mixers, principally testing grinders versus paddle mixers.

Amongst the essential facts to be determined before finally embarking on commercial development are the quantity of binder necessary, and the possible rate of operation of a press, to make satisfactory briquettes. As soon as it is established that these fall within the limits of economic possibility determined by a revised estimate of fixed and operating charges the Board could commence commercial operations.

Preliminary work on briquetting problems have been in progress for months and will be carried on. No dependable results can be obtained on many points until a power mixer and roll press are in operation. This cannot be before April 1. The time taken then to establish economic possiblity will depend entirely on the difficulties encountered.

After the above is successfully completed, further experiments should be carried on, possibly continuously until the work is transferred West, in order to reduce to the minimum the experimental and adjustment work to be done in the commercial plant.

7. — *Heat Treatment of Briquettes.* Investigation as to the feasibility of, and best method for rendering briquettes smokeless by heat treatment.

This work will be carried on simultaneously with 8. If the Board decides to make a smokeless fuel the results obtained will be as essential as those of 6, and the two problems will be inseparable. Proof that the briquettes made can be carbonized should be available without further delay. Design of a satisfactory retort for heat treatment may require further experimental work, and time, but this need not delay the preliminary work in the West.

8. — *Tests on Briquettes.* Investigations on the commercial value of the briquettes made, by such test as determinations of the fines made by handling, of the water absorbed and deterioration observable on storing in the open, and of their behavior in a furnace. This work will be carried on simultaneously with 6 and 7 and will cause no further delay.

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APPENDIX 38

Short description of Ottawa Experimental Plant

By R. A. STRONG.

In order to carry out the experimental research which was found to be necessary before a plant could be erected to demonstrate commercially the process of carbonizing and briquetting the Saskatchewan lignites, the Lignite Utilization Board made an agreement with the Mines Branch, Department of Mines, Ottawa, whereby this work was to be carried out in their laboratories located at the Fuel Testing Station. A small experimental plant was built adjoining the station, and the necessary machinery acquired and installed for briquetting investigations. This plant was designed for batch mixing only, in order that all possible binders could be tested, and such variables as enter into a briquetting process thoroughly investigated. The specific objectives of this investigational work are given in appendix 37 and the experimental plant layout is shown in Figure No. 3.

The crushing equipment consisted of a small roll crusher with corrugated rolls, and a ball mill. With this equipment any desired screen analysis was obtainable, and experiments were made to determine that which gave the best briquette.

The mixing apparatus consisted of a small Werner and Pfleiderer steam jacketed kneading machine, and a large horizontal mixer of original design. The former machine was used for small batch mixing in experimenting with various binders. By reason of its small capacity, which was eight pounds, a number of tests

could be made under different conditions of temperature and time of mixing. Steam for this mixer was supplied by a small boiler and connections were so arranged that steam could be blown into the mix as well as circulated in the jacket. The larger mixer was a single shell machine with two ribbon conveyors which served to mix the material and move it toward the center where it was discharged. The heating was accomplished by a series of gas burners directly beneath the mixer. This machine was used for larger batches as its capacity was approximately 50 pounds.

The press purchased was a Mashek, type Y-1, roll press which contained three rows of pockets on each roll. The capacity of the press was 3½ tons per hour and the briquettes produced were pillow shaped, weighing 1½ ounces. This type of press was selected on account of it being the smallest commercial machine possible to secure, and because the results obtained with such a press would be applicable to commercial operations with larger apparatus. A removable division in the press hopper was made in order to eliminate two rows of pockets on the rolls for use when experimenting with small batches.

In addition to the above equipment a small dryer was installed which was operated for the production of dried lignite used in the carbonization experiments. A drying plate, gas meter, and work bench completed the installation.

The work conducted in the Ottawa laboratories and experimental plant extended over a period of nineteen months. The carbonization researches had been started prior to the creation of the Board, and from its inception until the completion of the demonstration plant at Bienfait these experiments together with briquetting investigations, were continued. The results of the carbonization experiments are given in appendix 18 and the results of the briquetting investigations are fully described in Section VIII of the Secretary's report.

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APPENDIX 39.

Minutes of a meeting of the mine managers and operators of the Estevan Bienfait area with the Lignite Utilization Board, held at Estevan, Saskatchewan on Wednesday October 8, 1919.

Present:—R. A. Ross, Esq., Chairman, Lignite Utilization Board.
Hon. J. A. Sheppard, Member, Lignite Utilization Board.
J. M. Leamy, Esq., Member, Lignite Utilization Board.
W. Addie, Esq., Resident Manager, Manitoba & Saskatchewan Coal Co. Bienfait.
A. Millar, Esq., Resident Manager, Western Dominion Collieries Ltd. Taylorton.
R. Hazard, Esq., Bienfait Mine (Hosmer) Bienfait.
M. Hawkinson, Esq., Bienfait Commercial Bienfait.
H. Peterson, Esq., Coal Brick & Power Co., Shand.
Colin A. Manlove, Sec'y, Estevan Board of Trade.
F. W. Newcombe, Estevan Coal & Brick Co. Estevan.
Lesslie R. Thomson, Esq., Sec'y Lignite Utilization Board.

Minute 1

The meeting was called to order at 10 A. M. the chair being taken by Mr. Ross, who outlined, in opening, the history and present position of the Lignite Board. Mr. Ross further stated that the Board were taking this opportunity to consult the mine managers with the object of asking for certain information and advice on a number of points which would be discussed in order.

A. — *Location and site*

The Chairman called the attentiôn of the meeting to the importance of the question of site, owing to the fact, among others, of the variation of the ash content of the different mines. It was planned to produce roughly 100 tons of finished briquettes per day, and this would require from 250 — 275 tons of raw lignite. The capacity of the existing mines to supply this demand was discussed. The other important factors affecting the choice of location, would be freight charges in bringing raw material to the plant; freight charges in delivery of finished product to railway; water supply drainage; and housing.

B. — *Raw Material*

W. Addie, of the Manitoba and Saskatchewan Coal Co. Ltd., stated that, from their mine there would be no difficulty in getting during the winter, all the small sizes needed, say 30,000 tons, but during the summer it would be only possible to obtain run-of-mine. The price for the three small sizes would be from \$1.50 to \$1.60 F. O. B. mine. Run-of-mine coal would cost \$2.60 F. O. B. Mine. Mr. Millar of the Western Dominion Collieries, Ltd., agreed that the summer demand for small sizes was large. The following is a tabulated list of the commercial sizes used by the Western Dominion Collieries Ltd., and the Manitoba and Saskatchewan Coal Co., Ltd.

From 0 to 1″ screen........Slack
From 1″ to 1-½″ screen....Pea
From 1-½″ to 2-½″ screen-Cobble
From 2-½″ up............Lump

In the Hosmer mine they use only three commercial sizes, as Pea and Cobble sizes are mixed.

C. — *Storage*

Mr. Addie stated that if lignite were stored in the open in any quantity, fire would be certain to start sooner or later by spontaneous combustion. H. Peterson disagreed with this statement. Millar stated that fire was most likely to start in April and May.

Regarding the desirability of using air-dried lignite, Mr. Addie stated that his experience with air-dried lignite was not as satisfactory for boiler purposes as freshly-mined lignite. He quoted, as an example, the experience one of his firemen had had with one of the boilers. While using air-dried lignite, on chain grate stokers, it was impossible to keep up a certain pressure, but immediately after the firemen had soaked the lignite with water by means of a hose, no difficulty was encountered. Mr. Hawkinson's experience agreed with Mr. Addie's in this regard.

In closing this point, the Chairman agreed that storage should be avoided, if possible.

D. — *Water Supply*

The Chairman pointed out that the possible requirements of the Lignite Board, would be about 100,000 gallons per day. All present agreed that wells are not a feasible source of supply for this amount of water. Newcombe stated that in Estevan, the C. P. R. in addition to having access to the municipal supply, has installed a pumping unit and a 6″ pipeline from the Souris River.

Mr. Addie stated that they only found it necessary to use their pump from two to three hours per day, and also (speaking from memory) that the capacity was about 300 gallons per minute.

Mr. Millar stated that they got their water from the Manitoba and Saskatchewan Coal Co. and the price (speaking from memory) was not more than 10 cents per 1000 gallons.

Mr. Addie stated that two miles of 6″ pipeline had cost in 1912 — 1913 about $12,000 — $13,000.

E. — *Housing*

The population of Bienfait is three to four hundred persons. Mr. Addie's company owns sixty to seventy cottages. The population of Roche Percee is seventy to eighty. The population of Shand is about one hundred, while from Pinto, all have departed.

The Western Dominion Collieries mine has a population of about two hundred.

At the Manitoba and Saskatchewan Coal Co. there are twenty-five to thirty houses costing on the average about one thousand dollars, ($1000.00). These cottages possess concrete foundation and are finished with clapboard and plaster. There are also better class houses costing about two thousand dollars ($2000.00), details of which are to follow. Mr. Addie charges for the cheaper cottages, four dollars per month plus one dollar for coal supply and 50 cents for delivery. For the better class cottages, eight dollars per month plus one dollar plus 50 cents. Mr. Addie called our attention to the fact that their company had placed no restrictive regulations on the keeping of live stock etc., etc., by the employees. In this way, most of the employees keep themselves supplied with meat, eggs, etc. In addition they have the privilege of raising all their own vegetables in garden plots plowed at the expense of the company. Some years ago, Mr. Peterson built some brick cottages for six hundred dollars but recommended that the Board should expend about two thousand dollars on each house, otherwise employees would be apt to become discontented. Mr. Peterson rents his cottages at from seven to ten dollars per month.

F. — *Labour*

All labour in the Estevan — Bienfait area is on a ten hour shift basis, Pay is usually fixed by the rates paid by the C. P. R., who at present are paying forty cents per hour. The Manitoba and Saskatchewan Coal Co. however are paying at present 32-½—35 cents for surface work and 35—37-½ for underground work. There are no miners' unions whatever in the district, nor are there any general unions for other trades.

G. — *Shipping*

The shipping charge between the mines and Bienfait on either of the spurs is three dollars per car (equivalent to 10 cents per ton).

H. — *Market*

Mr. Addie's opinion is that the ordinary farmer will *not* buy lignite briquettes in any event, and the cities will become the real markets. On the other hand, Newcombe feels that the farmers will constitute a fairly good market.

I. — *Board's property*

The Chairman, in closing the meeting, called attention to the desire of the Lignite Board to locate their plant over as good a quality coal seam as possible, so that in the event of any combination being arranged of competing interests to refuse raw material, the Board would be in an independent position so far as raw material is concerned.

The meeting adjourned at 12:10.

APPENDIX 40

LIGNITE UTILIZATION BOARD

List of Contracts

Contract No.	With.	Description.	Commenced.	Finished.
1	C. P. Wilson & Company.	1 — 90,000 Gal. Water Tank (Second Hand)	Jan. 10/20	July 5/20
2	C. O. Bartlett & Snow Co.	2 — dryers.	March 15/20	June 16/21
3A	General Briquetting Co.	1 — second hand 15 ton Fluxer.		
		1 — new 15 ton Edge Runner.		
		1 — second hand 15 ton Press.	May 17/20	June 27/21
3B	Mashek Engineering Co.	2 — 10 ton Mixers.	May 15/20	Jan. 6/21
4	MacGovern Company.	1 — 100 k.v.a. Westinghouse Engine Generator (Second Hand).	April 16/20	Aug. 20/20
5	Smith Bros. & Wilson.	Plant Buildings and Houses.	April 30/20	Aug. 25/21
6	Vulcan Iron Works.	3 — 72″ x 18″ Return Tubular Boilers.	June 11/20	Jan. 10/21
7	Jeffrey Manufacturing Co.	Conveying Equipment.	June 7/20	Aug. 13/21
8	Jeffrey Manufacturing Co.	Raw Lignite Handling Equipment.	May 11/20	Aug. 13/21
9	Can. Sirocco Company.	Fans & Blowers.	June 16/20	June 3/21
10	United States Government.	1 — 400 k.v.a. Steam Driven Generator Set (Second Hand)	April 30/20	Feb. 4/21
11	Lincoln Electric Company.	All motors.	Aug. 24/20	Mar. 24/21
12	MacGovern Company.	1 — 25 Kw. Westinghouse Generator (Second Hand)	June 30/20	Dec. 16/20
13	Fraser & Chalmers.	1 — 3″ Lea & Courtenay Pump.	July 23/20	April 4/21
14	Moore, Cameron & Hill.	3 — Steel Hopper Bottom Cars — Second Hand.	Sept. 24/20	Nov. 26/20
15	Vulcan Iron Works.	Castings & Structural Steel for Carbonizers and Dryers.	Nov. 15/20	Sept. 30/21
16	Smith Brothers & Wilson.	Water Supply & Sewage, Sewage Systems.	Oct. 22/20	Dec. 14/20
17	United Electric Company.	Power Apparatus & Wiring.	Feb. 21/21	Sept. 3/21
18	Monarch Electric Company.	1 — 3 Panel Switchboard.	Feb. 23/21	July 12/21
19	United Electric Company.	Erecting and wiring, Telephone Line.	Nov. 4/20	Nov. 22/20
20	American Chemical Mach. Co.	Gas Purifying Equipment	Jan. 31/21	June 17/21
21	Gas Engineering Co.	1 — 5,000 Cu. Ft. Gas Holder.	April 29/22	Aug. 14/22

APPENDIX No. 41

Journal of Thomson's Visit to Mr. O. P. Hood, Washington

MONTREAL, *November 10th, 1922.*

1. Left Montreal, Rutland, 8.00 p. m. Tuesday, November 7th, to interview O. P. Hood, Chief Mechanical Engineer, Bureau of Mines, Washington, D. C.

2. Picked up Mr. C. V. McIntire at New York, Pennsylvania Station on Wednesday the 8th, and arrived Washington about 1.45. Proceeded at once to Bureau of Mines.

3. Opening interview, Mr. Hood outlined the history of lignite development in the Bureau that led to his recent trip to Germany. Sketched briefly this outline is as follows.—

   Work at Hebron, Grand Forks and Philadelphia had convinced Bureau that carbonization of lignite and briquetting the char was a process that had now become possible and workable. While further research might be necessary, no further doubt existed as to ultimate success if work be prosecuted with vigor. Large capital is needed, however, for necessary plant. It is difficult to go to a man with perhaps $50,000 invested in a mine, and say to him that by an investment of $1,000,000 he could save his slack and fine sizes. Bureau kept constantly looking for other and *alternative* solutions in order that they might serve the public. Briquetting is one solution, but there should be others with different objectives, available. Bureau had read naturally great deal of success of German methods, German apparatus, etc., etc. Hence decided to make personal investigation.

4. As a result of research work by Bureau they are now convinced that they can burn lignite char without briquetting it by means of a special base burner. In brief the details are:—

   Carbonized lignite is used in this burner in the sizes between split rice and split wheat. About 20% of it should go through a 16 mesh seive. The success of the burner was due to previous researches on zones that occur in a 6″ or 12″ bed of burning fuel. The important fact to grasp in connection with this research is that in a bed thicker than 3″ the oxygen in the air coming through the fire is absolutely used up. The upper zone in fire bed in a burner with a deeper bed than 3″ is practically a producer, hence a *glowing* lignite fire can only be obtained by a thin fire. This bed must not be thicker than about 2½″.

5. European psychology in regard to heating and burning of fuel in houses is vastly different from American psychology. In many cases either due to poverty or to want of personal experience with other methods, Germans are content with a small amount of heat in their houses — quite insufficient to warm a whole house, and often insufficient to warm a part of any given room. This distinction must be clearly grasped. None of the German stoves burning either briquettes or lignite char would satisfy an American householder for one instant. The American demands a radiant fire and plenty of heat, something that he can see as well as feel! He wants his house thoroughly heated but he also wants to see some radiancy in his fire. Hence the following notes on German practice, etc. are of interest from the point of view of general information rather than from the point of view of their applicability to our conditions.

6. Last year Germany produced about 400,000 tons of lignite char for domestic consumption. This, in the main, was burned in porcelain stoves or in the new type of stove looking not unlike an American refrigerator. In this stove, the burning is done in a drawer — hence the nickname of — "bureau drawer". In this drawer the lignite char burns slowly or perhaps smoulders. So far as Mr. Hood is aware no lignite char was briquetted in Germany. The brown coal briquetting industry is an industry for briquetting raw lignite entirely.

7. The German brown coals are very different from our own lignitic coals. Mr. Hood believes they possess distinct structural difference in which opinion the Lignite Board concurs. Mr. Hood stated from his experience in Germany, that no German brown coal, containing less than 2½% bitumen, was considered to be applicable for briquetting raw. Assuming for the moment that German and American nomenclatures are the same, the tar in our lignites does not run over 1¼%.

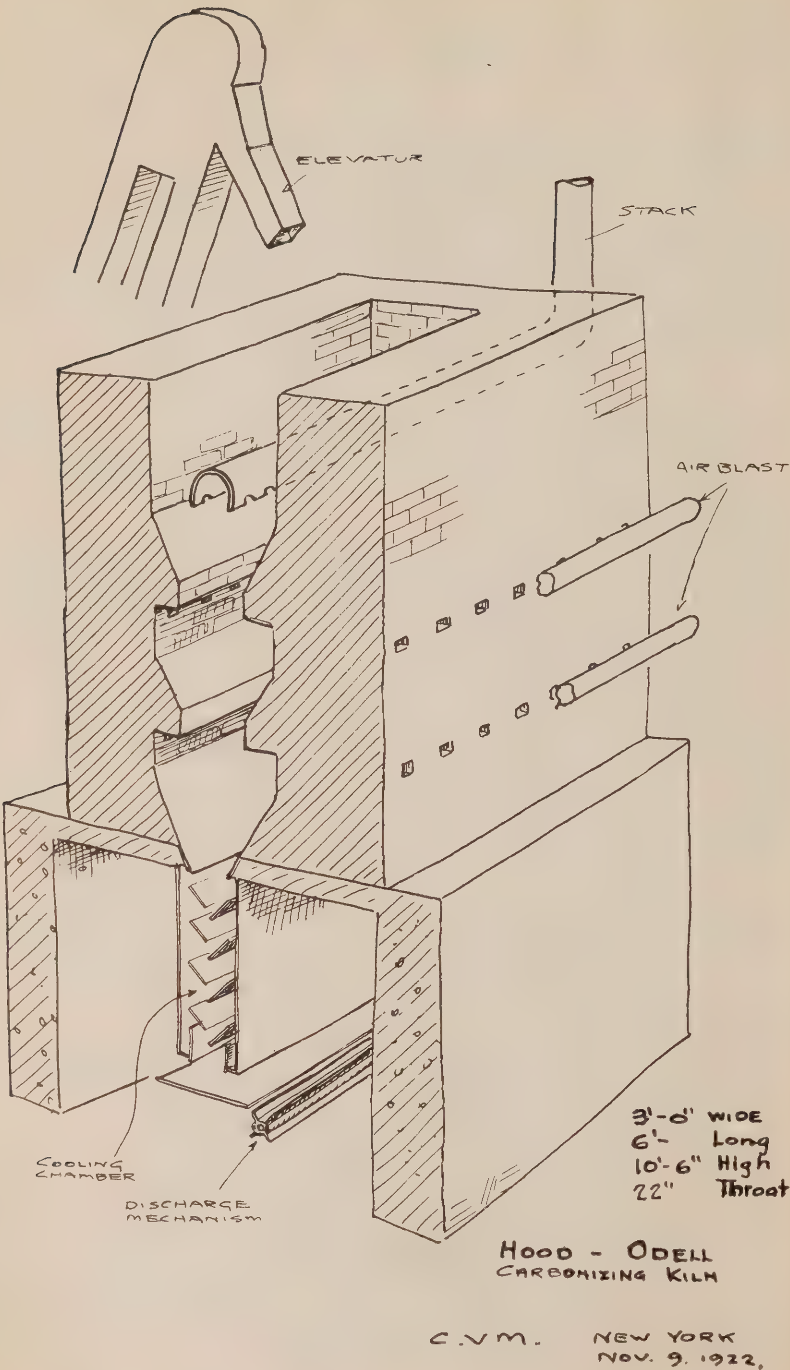
8. Mr. Hood next touched lightly on the mining methods used He emphasized the fact that owing to the difference in the characteristics of German brown coals and American lignites, there was an absolute divergence between German and American practice in the mining, handling, storing, carbonizing and briquetting. Many of the lignite beds are deposited in streaks or layers, alternately a dark brown layer and a light colored layer. In cases where deposits of this nature occur, the method practised is to briquette raw the coal from the dark colored layer and to carbonize the light colored coals. These light colored coals contain about 13% of bitumen paraffin compounds, and the resulting recovery of these furnishes materials for a considerable percentage of the world's supply of paraffin. It is said that about 2/3 of the candles of the world are made from this paraffin. The char resulting from this operation is the material that is supplied for burning in the "bureau drawer" stoves above mentioned.

9. The ovens used for making this light colored coal are standard, and resemble large tall chimneys, diameter of each 1½ meters, and are about 10′ centre to centre of chimneys. Surrounding the central space of these chimneys are spiral flues heated by gas. Each chimney contains about 500 sq. ft. of heating surface and has a capacity of about 5 tons of raw lignite per day. The passage of the lignite through the retort is accomplished and controlled much as in the Rolle process.

10. In summing up the general impression of his visit, Mr. Hood was quite emphatic in stating that it was his opinion that *no imported solution was going to be successful for our problem here.* We would have to work it out along our own lines by methods suitable for and appropriate to American conditions.

11. Mr. W. W. Odell was next called in and we had a pleasant conversation with him during course of which he outlined to us the work of the Hood-Odell carbonizing kiln at Grand Forks, which had been successfully tested by several long runs (as for example — 50 hours and 100 hours runs). The retort is an internally heated affair and the carbonizing is accomplished by the heat generated by the burning of the gas and of a portion of the charge. The general features of the oven are shown on sketch No. 1 prepared by Mr. C. V. McIntire. Consumption of lignite necessary to carbonize remaining charge is about 5%, and not more than 10%. Capacity is 16 tons per day of raw lignite. I regard this retort if successful as a very important contribution to the development of the lignite industry.

12. Mr. Hood stated that he is having chemists look into the question as to whether the German terms "paraffin," "bitumen," etc. mean the same thing as they do when used by ourselves. Mr. Hood stated that he would let us know the answer in due course.


ELEVATUR
STACK
AIR BLAST
COOLING CHAMBER
DISCHARGE MECHANISM
3'-0" WIDE
6'- Long
10'-6" High
22" Throat
HOOD - ODELL
CARBONIZING KILN
C.V.M.
NEW YORK
NOV. 9. 1922.

SKETCH No. 1.

13. I mentioned to Mr. Hood that we were getting a complete line of German and Australian lignite samples, and would be glad to furnish him with some on its arrival. I told him that the Australian lignite samples would be here at any time now, but that the German samples might take some little while yet owing to the fact that the matter was being arranged for us by the Canadian High Commissioner in London.

14. I told Mr. Hood that L. U. B. was in thorough accord with his idea that carbonizing and briquetting was only one of other possible solutions.

15. Left Washington at midnight, reaching N. Y. on Thursday morning and Montreal on Friday a. m. the 10th.

NOTE:—*A copy of this journal was sent to Dr. Charles Camsell, Deputy Minister of Mines, Nov. 13, 1922.*

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APPENDIX No. 42

Course of Action Recommended by L. U. B. in December 1922, with Analysis and Digest of various Alternatives Facing the Board at that date.

RECOMMENDATIONS.

In view of the present position and of the accomplishments of the Board, and in view of the ultimate necessity of providing domestic fuel from the lignite deposits of the Canadian West, the national importance of which demands a solution at some time, somehow, by some body, the Board recommends:—

(a) That a period of 4 to 6 months of plant operation be entered upon practically immediately, even though said operation cannot be undertaken on a purely commercial basis.

(b) That the Board procee tdo requisition the three Governments for the balance of the money they asked for in February 1922.

The reasons that led the Board to make the above recommendations are developed in the balance of this report. In order to make it brief, everything has been condensed to the smallest space.

ARGUMENT.

The proper procedure to undertake at the present time will be ascertained most easily:—
(a) By making a brief digest of the real present position of plant and of the affairs of the Board.
(b) By stating afresh the objectives the Board set out to reach.
(c) By comparing how closely the results obtained have approximated the original objectives.
(d) By determining what courses of action will most rapidly fill in any gaps that may be discovered between accomplishments and objectives.

PRESENT POSITION OF BOARD.

PLANT

DEPARTMENT	CONDITIONS
Raw Lignite Handling	Satisfactory.
Carbonizers	Not yet successful, but on other hand not a proven failure. So far our faith has been pinned to one retort only. Other possible retorts have been developed during past few months, however.
Briquetting	Mechanical layout not entirely satisfactory but machinery *can be made to go* if determination be shown. Good briquettes have been produced now.
Cooling	Satisfactory.
Storing	O. K.
Power	Satisfactory.
Water Supply and Sewage.	Satisfactory.

Above represents situation of *Plant*.
Present situation of business end of Board's project is:—

Staff and Organization	Satisfactory and economical
Marketing	Not yet attempted but no great difficulties anticipated.
Costs	Present costs worthless

OBJECTIVES OF BOARD.

(a) The Board's objectives are to demonstrate a process of producing a carbonized lignite briquette for domestic consumption.

(b) To determine commercial costs during such demonstration.

RELATION OF ACCOMPLISHMENTS TO OBJECTIVES.

(a) The Board has not yet demonstrated a process. Not one pound of lignite has gone through the plant on continuous operation.
(b) The Board has not yet been completely successful in carbonizing. On the other hand it has made very large strides towards success.
(c) The present costs are of but little value.

POSSIBLE COURSES OF ACTION

There are apparently four and four only courses of action open to the Board.

1. To shut down the plant completely and immediately, wind up the Board's affairs, and report to the governments concerned.
2. To stop temporarily and revise the plant to suit the ideas and opinions developed within the last few months, and thereafter make another attempt to operate.
3. To concentrate on one part only of the plant, — say carbonizing — and solve it. At the same time to have some studies made of alternative retorts in case success should not attend our present efforts.
4. To embark almost immediately on a continuous operating period, irrespective of cost, and to concentrate all efforts at producing maximum quantity of briquettes. At the same time gather information on the possibility of other retorts. This operating period should be from 4 to 6 months' duration — depending on life of our 3 retorts under service.

DISCUSSION OF ABOVE COURSES OF ACTION.

(a) *Discussion of Course 1.*

The Board believes the first course of action to be untenable because the Board can only state that it regards the work to date as fairly successful though distinctly unfinished.

(b) *Discussion of Course 2.*

Present information would enable Board to make certain changes of which we are sure — for example — in the briquette building. The Board believes it to be an open question whether enough fresh knowledge has been gained to justify the Board in attempting immediate changes on the carbonizers. To sum up the discussion, the reasons pro and con are tabulated below.—

FOR COURSE 2.	AGAINST COURSE 2.
You obtain certain improvements in plant and thereby increase chances of ultimate smooth running.	Changes of which we are sure are not absolutely essential.
Economical.	Lack of knowledge to make more far reaching changes.
	Delay — involving a large increase of public criticisms. Hence more difficult for obtaining balance of money.
	Delay might run to a whole year.
	No briquettes produced.

The Board believes the balance of argument is in favor of rejection of Course 2.

Discussion of Course 3.

Course 3 presents many attractive features. The complete discussion of it can be summed up in tabular form:—

FOR COURSE 3.	AGAINST COURSE 3.
Economy	No briquettes produced.
Almost sure solution of carbonizer problem because on full scale, and efforts concentrated.	No continuous process.
Alternative carbonizer available at end of period.	No costs of value. Public not encouraged. In fact sure increase of public criticism.

The Board believes the balance of argument is in favor of rejection of Course 3.

Discussion of Course 4.

We next consider Course 4. Again the reasons are tabulated.

FOR COURSE 4.	AGAINST COURSE 4.
Continuity of process. Briquettes are produced. Data on real life of retorts. We determine whether plant is an articulated whole. Public approval on sale of briquettes with resulting improvement in chances of getting further financial support, hence complete objective of Board. If our retorts a failure, then we have an alternative ready if possible.	Costs will be very much higher than they should be, in fact operation will not be commercial.

The Board believes that balance of argument is in favor of the adoption of Course 4, provided financial conditions permit.

APPENDIX 43

DATA SHEETS.

No.	
I	Diagram showing relation of mixing ratio to "Percent Binder".
II	Western Freight Rates on Coal (J. G. S. Hudson).
III	Binders (3 sheets).
IV	Effect of Heat on Concrete.
V	Coal brought into Winnipeg, May 1918 to Jan. 22, 1919,—P. Brereton (2 sheets).
VI	Provincial Fuel Controllers.
VII	Weight of Gases.
VIII	Description of samples and analysis — McLean's samples from Estevan Field (4 sheets)
IX	Color and Temperature.
X	Analysis of Canadian Coals — Bulletins 22-26 Mines Branch, Stansfield & Nicolls.
XI	Composition of coals — Tech. paper 76, U.S. Bureau of Mines.
XII	Summary of Binder Experiments — E. Stansfield (2 sheets).
XIII	Survey of Briquetting plants visited on Investigatory trip.
XIV	Bibliography of briquetting (3 sheets).
XV	Map showing producing coal fields of Canada.
XVI	Products of Carbonizing one ton of lignite from Sask. Coal, Brick and Power Company's mine, Shand, Sask.
XVII	Balance sheet — carbonization of raw lignite from Sask. Coal Brick and Power Company's Mine, Shand, Sask. (2 sheets).
XVIII	Composition of lignites, Bulletin 22, U.S. Bureau of Mines.
XIX	Loss of heat through furnace, walls — J. Bied.
XX	Boiler tests — Regina Municipal Power Plant — Feb. 18, Mar. 15, 1917.
XXI	Physical properties of refractories (2 sheets).
XXII	Heat transfer through walls (Alfred Stansfield).
XXIII	Notes on carborundum refractories (2 sheets).
XXIV	Effect of heat on Iron and Steel (prepared by H. W. Craver).
XXV	Radiation of Heat (3 sheets).
XXVI	Useful Equivalents.
XXVII	Rapid lignite carbonization (in muffle at 1472° F.).
XXVIII	Drying and Absorbtion curves for pulverized lignite in 60% Humidity air
XXIX	Carbonization curves (3 sheets).
XXX	Analysis of Shand lignite, Raw, Dried and Carbonization.
XXXI	Carbonized residue, lignite carbonization.
XXXII	Gas results, lignite carbonization.
XXXIII	Tar results, lignite carbonization.
XXXIV	Products per short ton of different lignites from Estevan field.
XXXV	Form for screen analyses.
XXXVI	Water Analysis from Bienfait.
XXXVII	Records of briquetting experiments — series 96-147.
XXXVIII	Nozzle discharge curves.
XXXIX	Screen analysis of coal briquettes.
XL	Analyses of briquettes.
XLI	Screen analyses of Crushed lignite.
XLII	Screen analyses of Carbonized lignite.
XLIII	Map and Sections of Taylorton Lignite Field to accompany notes by A. MacLean Dec. 2nd, 1919.
XLIV	Notes on Water supply — Souris district — A. MacLean.
XLV	Information on lignite areas in Taylorton Dist. A. MacLean (2 sheets).
XLVI	Chart of screen analysis of raw lignite.
XLVII	Briquetting results — carbonized Nov. 19th, 1919 (2 sheets).
XLVIII	Air drying of carbonized lignite briquettes.
XLIX	Analysis of composite charge and discharge samples.
L	Gas data — vapor pressure of water.
LI	Gas results — Moist Shand lignite.
LII	Gas results — Comparative series.
LIII	Perfect combustion in air.
LIV	Results General Briquetting Co's briquetting tests.
LV	Chart kind of coal B.T.U. percent by weight.
LVI	Tests on briqueetes.
LVII	Screen analyses of carbonized residues (Lignite in batches used in table LVI).
LVIII	Chemical analyses of carbonized lignite (Lignite in batches used in table LVI)
LIX	Minimum angles of slip.
LX	Tests on firebrick — "Claybank" and "Clayburn".
LXI	Comparative analyses of briquettes and coals.
LXII	Classification of coals.
LXIII	Physical charateristics of lignite tar.
LXIV	Analyses of lignite ash.
LXV	House heating test.
LXVI	Freight rates on Western Canadian Coal.

APPENDIX No. 44

General Ledger Trial Balance. December, 31st 1923.

			Dr.	Cr.
General Expense Group				
Engineering Administration				
Account	A10	Office Supplies, Misc. Expenses	$7,220.00	
"	11	Rent, Light, Taxes & Insurance	6,198.76	
"	12	Petty Cash	1,291.95	
"	13	Salaries	113,434.07	
"	14	Reports, Investigations, Legal Fees	13,448.85	
Travelling Expenses				
Account	B20	Members of Board	2,194.76	
"	21	Members of Staff	10,667.54	
Miscellaneous				
Account	D40	Miscellaneous Expense	8,074.98	
"	41	Interest and Exchange	256.09	
Cash				
Bank of Montreal			57,956.54	
Liabilities to Governments				
Appropriations				
Dominion Government				$696,292.96
Saskatchewan "				170,000.00
Manitoba "				170,000.00
Earnings				
Interest and Discount				
Interest on Savings Account				13,261.13
" " Current Account				332.82
Discount on Purchases				376.09
Capital and Operating Expenditure Group.				
Office Equipment and Library.				
Account C30			$1,948.04	
Buildings				
Plant Account			216,866.36	
Houses Account			117,749.77	
Machinery and Equipment				
Account	A	Raw Lignite Handling	27,900.29	
"	B	Drying	53,487.95	
"	C	Carbonizing	64,995.48	
"	D	Mixing and Briquetting	47,395.06	
"	E	Storage and Unloading	2,735.72	
"	F	By-Product Recovery	40,516.99	
"	G	Yard and Switches	13,623.27	
"	H	Water Supply and Drainage	36,751.99	
"	J	Power and Power House	67,755.90	
"	K	Office and Laboratory	7,567.06	
"	O	Machine Shop Equipment	5,527.94	
"	P	Small tools and Equipment	1,827.15	
		Auto Equipment	2,374.12	
		Fire Protection Equipment	855.69	
		House Property Equipment	681.40	
		Boarding House Equipment	2,931.04	
		Pipe Line	3,986.22	
Stores			5,448.48	
Distribution Suspense			30.25	
Plant Preliminary Expenses				
General			8,916.43	
Office and Laboratory			1,907.12	
Boarding House			1,732.90	
Operating			29,275.02	
Experimental			5,485.14	
"		Grand Forks, Carbonizing	1,745.56	
"		Grand Forks, Briquetting	124.19	
"		Hebron "	2,733.63	
Reconstruction			12,202.19	
Repairs and Maintenance			7,853.60	

HOOD-ODELL OVEN SYSTEM		
Capital		
HO 350 Oven	$3,874.24	
" 353 Raw Lignite Handling Equipment	621.92	
" 356 Gas Handling Equipment	350.33	
Operating		
HO 351 Oven	10,941.86	
" 354 Raw Lignite Handling	639.86	
" 357 Gas Handling	160.82	
Repairs and Maintenance		
HO 352 Oven	301.05	
" 355 Raw Lignite Handling	65.15	
" 358 Gas Handling	126.73	
Char Storage and Advertising Expense	332.43	
Experimental Expense	477.93	
Miscellaneous Expense	758.62	
Insurance	14,004.51	
Taxes	3,534.80	
Sundry Services		
To Houses	1,309.43	
Staff	98.10	
Special Orders		127.58
Bienfait Mine		115.18
E. V. Campion & Co		2,085.02
C. P. R. Claims	9.76	
Crescent Collieries Ltd		53.75
Mrs. Graham	12.75	
Lignite Coal Mines Ltd		234.33
Lukis Stewart & Co. Ltd		348.55
M. & S. Coal Co. Ltd.		
(Accts Payable......... 887.75)		
(Accts Receivable....... 443.34)		444.41
Ivor F. Roche Trust a/c		1,534.88
Western Dominion Collieries	1,934.05	
H. P. Stanley		23.13
	$1,055,229.83	$1,055,229.83

NOTE:—General Revenue a/c; Balance in Bank December 31st 1923, $9,040.44.

APPENDIX 33

Memorandum of Statements made in June 1923 by Manufacturers of High Temperature metals regarding their respective products.

Note. The information contained in this table is not guaranteed by the Lignite Utilisation Board, nor is any responsibility for statements or accuracy accepted. The information is submitted entirely without prejudice.

Name of Metal and Manufacturer	Approx. Composition	Price	Actually used in practice and where	PHYSICAL PROPERTIES: Extreme temp °F	Working temp. °F.	Sp. Gr.	Can it be forged	Can it be welded	Can it be [illegible]	HOW OBTAINED	REMARKS
Driver Harris, Harrison N. J.: N. [illegible]	Ni -66% Cr -16% Fe-18%	$. 80 — 1.20 per lb. f o b. Harrison N. J 20 cents scrap value	As retorts — No. In connection with gas masks. — Yes. See Wheeler — Woodruff Co., New York.	2100°	1900°	8.15	Yes	Yes	Yes	Rolled Sheets & Castings	Driver Harris Max. casting capacity is 3,000 lbs. per pour. This alloy is non absorbing to C
Driver Harris, Harrison N. J.: [illegible] Alloy or [illegible]	Cr [illegible] [illegible] 72-73 [illegible]	[illegible] 70 f o b Harrison	Yes — [illegible] letter to [illegible]	[illegible]	1750°	7.[illegible]	[illegible]	[illegible] low C Cimets, by oxy-acetylene	[illegible] up, No. If 0 15 C, Yes	[illegible] (still experimenting) Castings commercial	[illegible]
Duraloy[illegible] Cutler Steel Co., 50 Church St., N. Y.	Cr 25 Fe. — 70	[illegible] .60-65 Castings f. o b. Pittsburg	[illegible] Falls Though grave troubles encountered, Cutler people claim alloy is O K.	2100°	1900°	7.60	[illegible]	[illegible] elec. arc, or oxy.-acet. Not by hammer	[illegible]	[illegible] castings Tubes experimentally.	[illegible] Max cap. is 5,000 lbs per pour
"Thermalloy" Electro-Alloys Co., 50 Church St., N. Y.	Formerly Fe 75-85 Cr 10-20 Si 2- 6 Mg 15- 1 Ti [illegible]- 1 Ca. .2- 2	.05 cents scrap value .12 cents f o b Elyria, O.	Not to be used in conjunction with carbonaceous material. Jones-Laughlin Co., See. E -A. Co. letter of 20-ii-23	2200°	1800°			Yes oxy-acet.			[illegible] Patent No. [illegible] made about same as Cimets.
Hybnickel Pusey & Jones Co., Wilmington	Ni. 35 Cr. 15 Fe 50	50 cents lb. 20 cents scrap value	Yes. 15" Ø cyl retorts Atlas Powder Co. Wilmington, Del See letter from Webster dated March 5th, 1923.	2100°	2000°		Yes		Yes	Castings	8,000 hours guaranteed at 2100° for Atlas Powder
Calite Colorising Company of Pittsburg, Pittsburg, Pa.	Al Ni Fe.	80 a lb. f o b. Lynn, Mass., plus patterns		2200°	2000°	7.03	No.	No	No	Castings only	
Hardite Hardite Metals Inc. 103 Park Ave. New York.	Ni 80 Zr. Non [illegible] [illegible]								Yes		
Nichroloy— Hiram Walker & Sons Metal Products Ltd, Walkerville	Ni Cr. Fe.	$ .80-1.00 lb. f. o. b. Walkerville,								Castings only	300 lbs. limit of pour

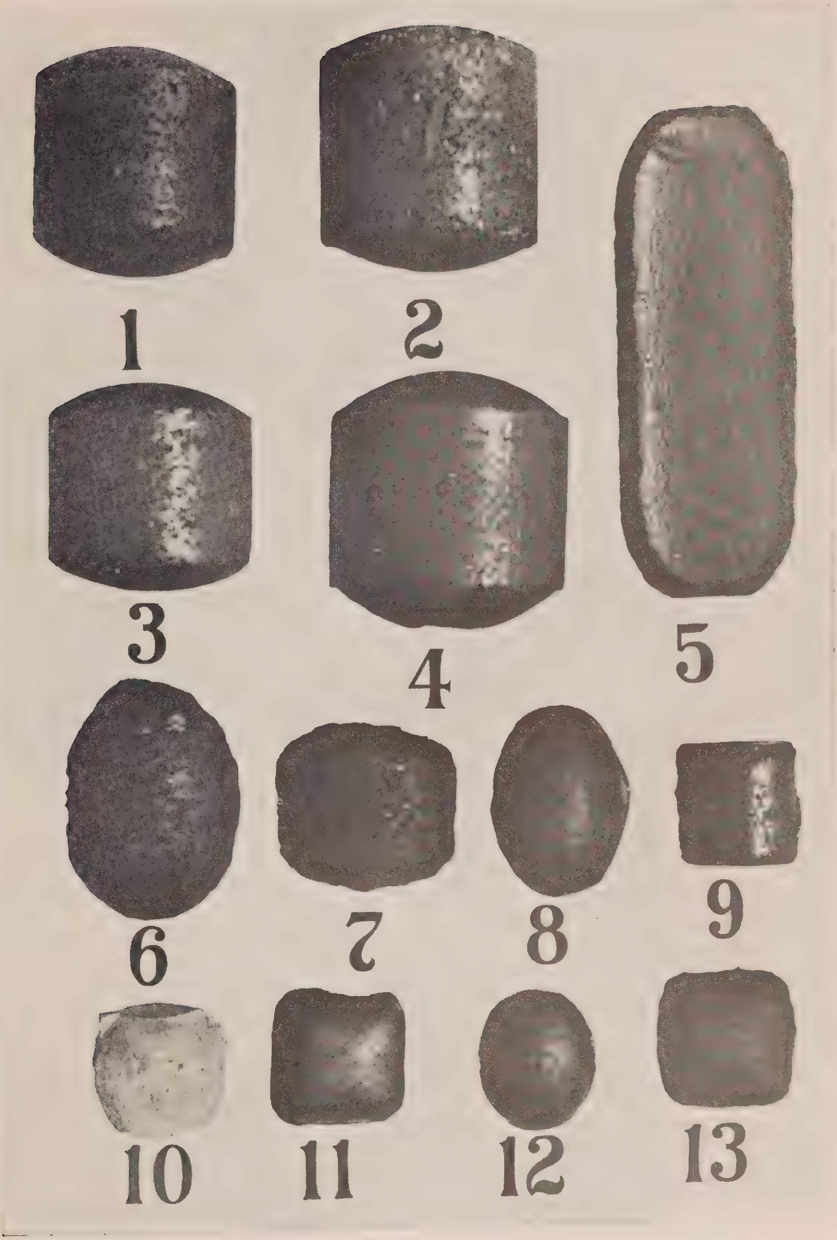
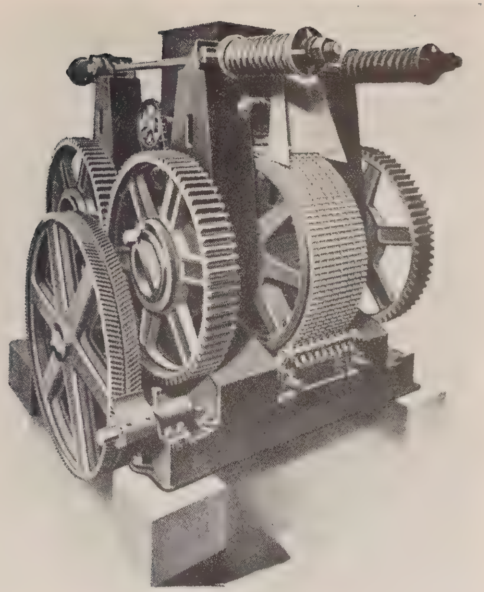


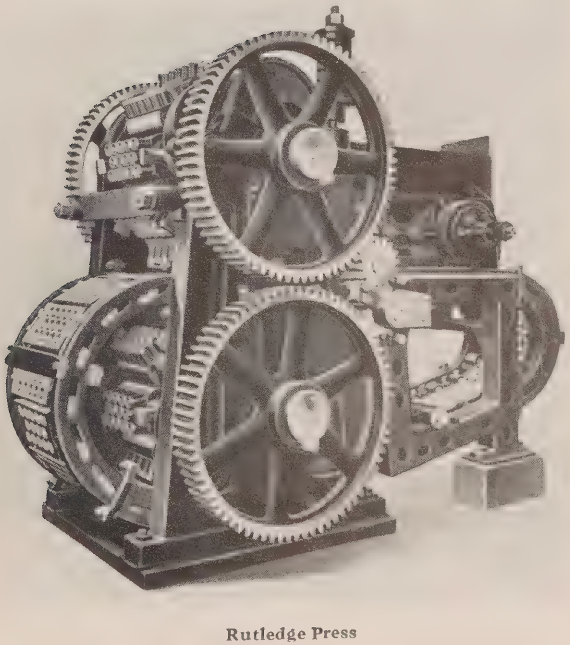
PLATE 1

Products of Briquette plants in North America

For text reference see page 145



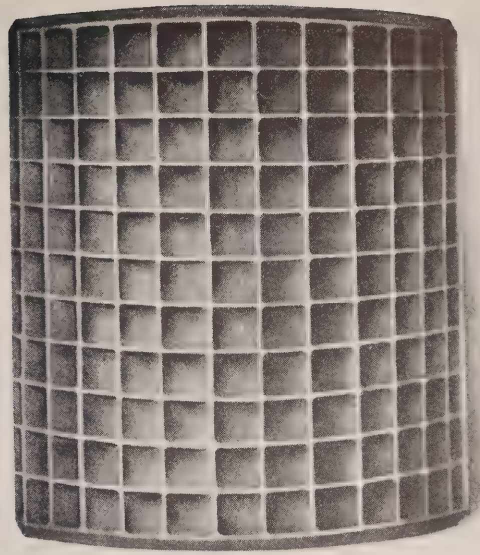
Komarek Press



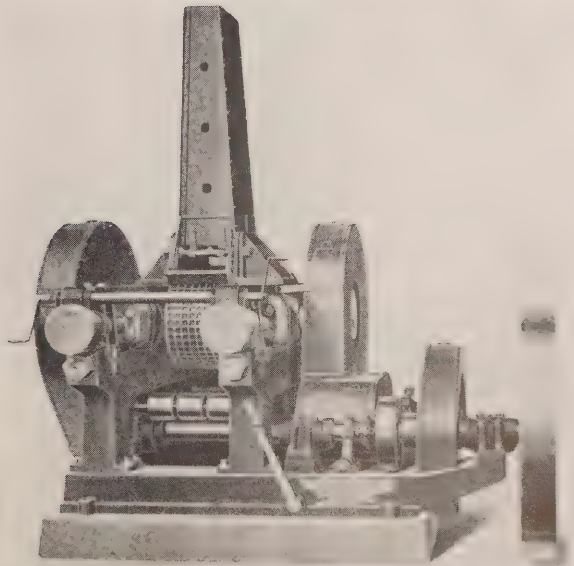
Rutledge Press

PLATE 2

For text reference see page 149



Roll Press Shell



Roll Press

PLATE 3

For text reference see page 149

PLATE 4
Construction of Bienfait Plant June 11th, 1920
For text reference see page 183

PLATE 5

Construction of Bienfait Plant July 20th, 1920

For text reference see page 183

PLATE 6

Construction of Bienfait Plant Nov. 8th, 1929

For text reference see page 183

PLATE 7
View of Completed Bienfait Plant
For text reference see page 183

PLATE 8
View of Bienfait Plant and Dwellings
For text reference see page 183

Plate 9

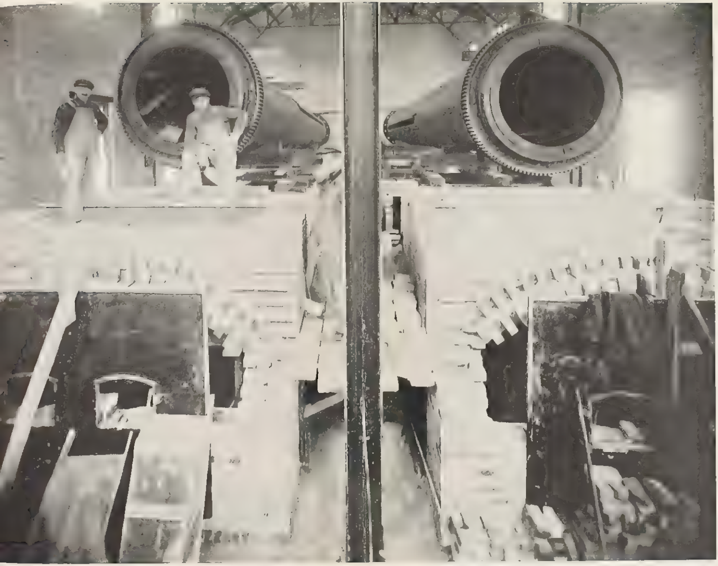


PLATE 9
View of Interior of Dryer Shells and Brickwork setting
For text reference see page 183

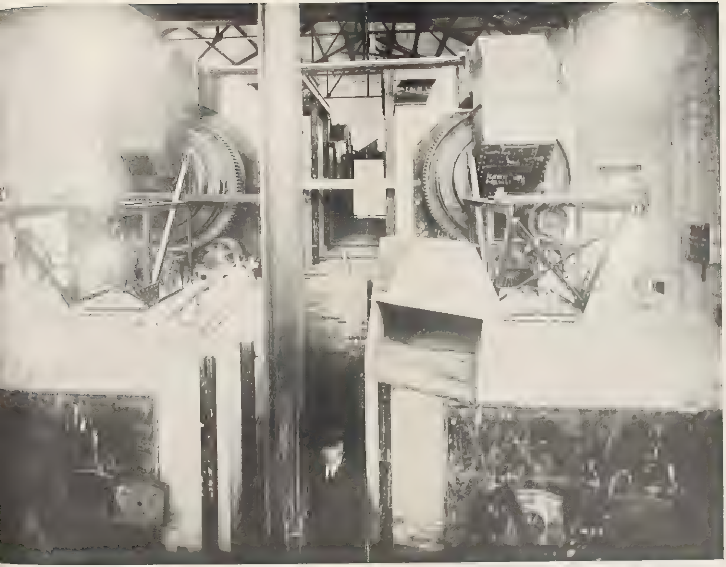


PLATE 10
View showing dryer feeding mechanism and furnace
For text reference see page 183

Plate 11

PLATE 11
View of Hood-Odell shaft carbonizer, Bienfait
For text reference see page 219

PLATE 12

View of Hood-Odell shaft carbonizer, Bienfait

Circular structure in background is raw lignite storage bin

For text reference see page 219

PLATE 13
View of Hood-Odell shaft carbonizer, Bienfait
For text refecnce see page 219

PLATE 14

Section of a pile of about 200 tons of North Dakota Lignite Briquettes made at the Mining Sub-Station, University of North Dakota. Notice perfect condition after standing weathering tests for several months.

Courtesy of Dr. E. J. Babcock, Dean of the College of Engineering, University of North Dakota

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a Lignite Briquettes made at the Mining Sub-
t condition after standing weathering tests for

of Engineering, University of North Dakota.*

Fig. 2

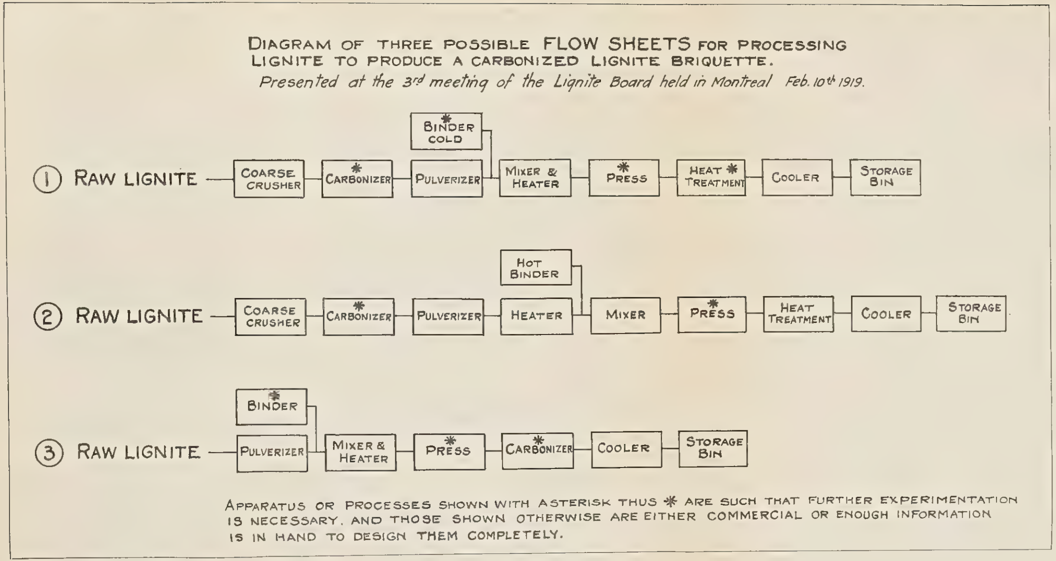
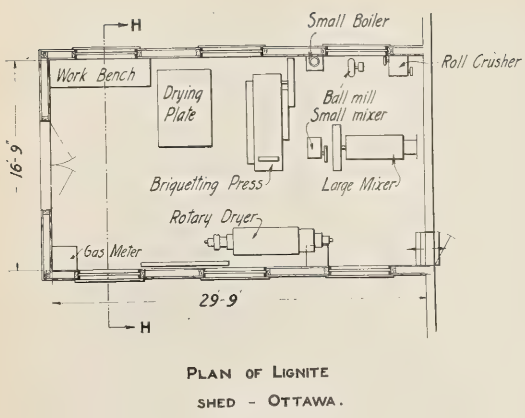


FIGURE 2

Three typical flow sheets of Carbonizing and Briquetting Processes

For text reference see page

Fig. 3



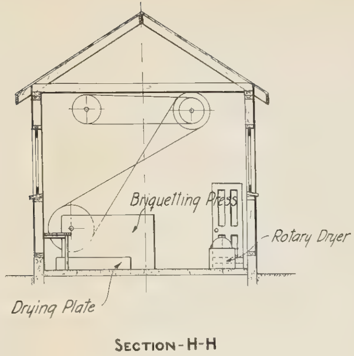


FIGURE 3
Layout of L. U. B. Experimental Plant, Ottawa
For text reference see pages 31 and 253

Fig. 4

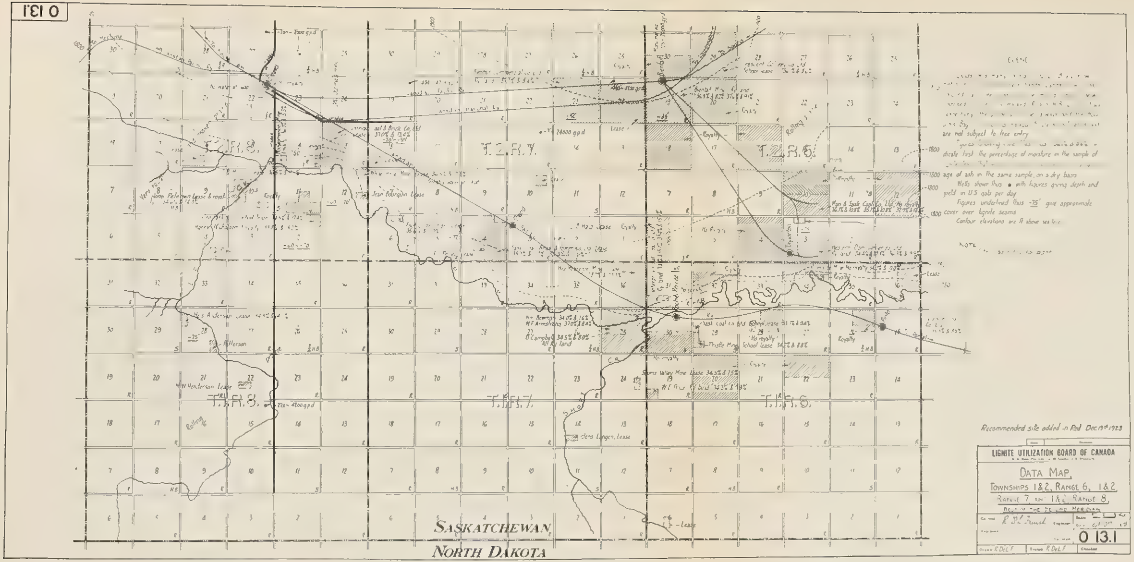


FIGURE 4

Data map of Estevan and Bienfait area showing site

For text reference see pages 37 and 182

Lignite Utilization Board of Canada. Summary of Tenders, Contract No. Five, Buildings, etc.

Group 1.

Rank	Tenderer	Address	Estimate	Excavation Cu. yds.	Unit price	Total	Rank	Backfill Cu. yds.	Unit price	Total	Rank	Group total
1	Smith Bros. & [illegible]	Regina Sask.	$50,243.25	4700	2.50	11750.00	6	3100	1.00	3100.00	[illegible]	4850.00
2	F. R. Graham	Moose Jaw Sask.	160,0[illegible]3.00	"	1.25	5875.00	2	"	0.50	1550.00	2	7425.00
4	Poole Constr. Co. Ltd.	Regina Sask.	1[illegible]3,497.90	"	[illegible]	[illegible]	5	"	[illegible]	[illegible]	4	11335.00
3	Standard Constr. Co. Ltd.	[illegible] Sask.	162,239.90	"	.75	3525.00	1	"	.20	620.00	1	4145.00
5	Sanderson & Porter	[illegible]	189,395.75	"	1.50	7050.00	3=	"	.90	2790.00	5	9840.00
6	D. G. Loomis & Sons	Montreal Que.	90,680.00	"	1.50	7050.00	3=	"	.50	1550.00	2=	8600.00
7	Raymond Con. Pile Co. Ltd.	" "	[illegible]	"	[illegible]	[illegible]	7	"	[illegible]	4092.00	7	[illegible]
	Engineer's Estimate		[illegible]3386.00	7436▼ 2479▼	.35 .40	2[illegible] 992.00		3273	0.29	949.00		4036.00

Group 2.

Rank	Tenderer	2-4 Concrete Cu. yds.	Unit price	Total	Rank	1-2½-5 Concrete Cu. yds.	Unit price	Total	Rank	1-3-6 Concrete Cu. yds.	Unit price	Total	Rank	Group total
1	Smith Bros. & [illegible]	250	11.50	2875.00	1	840	[illegible]	[illegible]		700	[illegible]	3500.00	1	19549.00
2	F. R. Graham	"	25.00	6250.00	5	"	18.00	15120.00	3		15.00	10500.00	2	[illegible]
4	Poole Constr. Co. Ltd.	"	[illegible]	[illegible]	4	"	[illegible]	[illegible]	4=	"	[illegible]	[illegible]	4	[illegible]
3	Standard Constr. Co. Ltd.	"	[illegible]	4750.00	3		[illegible]	[illegible]	4=		[illegible]	[illegible]	6	[illegible]
5	Sanderson & Porter	"	[illegible]	4375.00	2	"	[illegible]	[illegible]	2		[illegible]	5500.00	3	[illegible]
6	D. G. Loomis & Sons	"	35.00	8750.00	6	"	30.00	25200.00	6	"	18.00	12600.00	5	46550.00
7	Raymond Con. Pile Co. Ltd.	"	[illegible]	[illegible]	7	"	[illegible]	[illegible]	7	"	36.00	25200.00	7	[illegible]
	Engineer's Estimate	37● 153●	21.8[illegible] 28.75	[illegible] 4329.00		[illegible]	[illegible]	15960.00		[illegible]	[illegible]	[illegible]		[illegible]

Group 3.

Rank	Tenderer	Reinforcing steel Pounds	Unit price	Total	Rank	Brick Thousand	Unit price	Total	Rank	Structural steel Pounds	Unit price	Total	Rank	Group total
1	Smith Bros. & [illegible]	48000	0.07	3360.00	[illegible]	380	38.00	14440.00	2			48839.00	2	66639.00
2	F. R. Graham		.09	4320.00	6		42.00	15960.00	4			53724.00	6	74004.00
4	Poole Constr. Co. Ltd.		[illegible]	[illegible]			[illegible]	[illegible]	3	[illegible]		[illegible]	5	[illegible]
3	Standard Constr. Co. Ltd.		[illegible]	[illegible]	2	"	35.00	13300.00				48000.00	1	64420.00
5	Sanderson & Porter	"	.10	4800.00	6		48.50	18430.00	5		3½	48640.00	3	[illegible]
6	D. G. Loomis & Sons	"	.08	3840.00	4		50.00	19000.00	6		[illegible]	49000.00	4	[illegible]
7	Raymond Con. Pile Co. Ltd.	48000	[illegible]	4700.00	1	"	[illegible]	22800.00	7			53000.00	7	[illegible]
	Engineer's Estimate	32000	[illegible]	2835.00		362	42.50	15385.00				[illegible]		[illegible]

Group 4.

Rank	Tenderer	Lumber M ft. B.M.	Unit price	Total	Rank	Shingles Thousand	Unit price	Total	Rank	Group total
1	Smith Bros. & [illegible]	22	80.00	1760.00	[illegible]	9	12.50	112.50		1872.50
2	F. R. Graham		90.00	[illegible]	"		15.00	[illegible]	3=	[illegible]
4	Poole Constr. Co. Ltd.	"	[illegible]	[illegible]	3=		[illegible]	[illegible]	2	[illegible]
3	Standard Constr. Co. Ltd.	"	[illegible]	[illegible]	3=	"	15.00	135.00	3=	[illegible]
5	Sanderson & Porter	"	55.00	[illegible]	7	"	200.00	1800.00	7	[illegible]
6	D. G. Loomis & Sons	"	[illegible]	[illegible]	5	"	[illegible]	[illegible]	5	[illegible]
7	Raymond Con. Pile Co. Ltd.		[illegible]	[illegible]	6	"	[illegible]	[illegible]	6	[illegible]
	Engineer's Estimate	21	[illegible]	1752.00		11	.725	[illegible]		[illegible]

Group 5.

Rank	Tenderer	Corrugated steel Sq. ft.	Unit price	Total	Rank	Tar and gravel roofing Squares	Unit price	Total	Rank	Group total
1	Smith Bros. & [illegible]	23000	0.37	8510.00	1	95	[illegible]	[illegible]	4	[illegible]
2	F. R. Graham	"	.20	[illegible]	2		[illegible]	[illegible]	3	[illegible]
4	Poole Constr. Co. Ltd.	"	.30	[illegible]	4=		5.50	[illegible]	5	[illegible]
3	Standard Constr. Co. Ltd.	"	.22	[illegible]	3	"	[illegible]	[illegible]	2	[illegible]
5	Sanderson & Porter		.35	8050.00	[illegible]	"	8.00	[illegible]	1	8800.00
6	D. G. Loomis & Sons	"	[illegible]	[illegible]	4=		[illegible]	[illegible]	7	[illegible]
7	Raymond Con. Pile Co. Ltd.	"		[illegible]	1	"	[illegible]	[illegible]	6	[illegible]
	Engineer's Estimate	2025▲ 564▲	28¾ 35	582.00 [illegible]		[illegible]	[illegible]	[illegible]		[illegible]

Group 6.

Rank	Tenderer	Lathing and plastering Sq. yds.	Unit price	Total	Rank	Composition floors Sq. yds.	Unit price	Total	Rank	Group total
1	Smith Bros. & [illegible]	050	1.10	55.00	3	65	3.75	243.75	2	1398.75
2	F. R. Graham	"	.85	[illegible]	[illegible]		[illegible]	[illegible]		994.00
4	Poole Constr. Co. Ltd.	"	[illegible]	[illegible]	5		[illegible]	[illegible]	3	[illegible]
3	Standard Constr. Co. Ltd.		.85	[illegible]	[illegible]		[illegible]	[illegible]	4=	[illegible]
5	Sanderson & Porter		1.50	1575.00	4		6.75	[illegible]	7	[illegible]
6	D. G. Loomis & Sons		2.00	[illegible]			2.00	130.00	6	2850.00
7	Raymond Con. Pile Co. Ltd.	"	3.50	[illegible]	7		[illegible]	33[illegible]	4=	4170.00
	Engineer's Estimate	022	1.15	75.00		61	3.87	236.00		[illegible]

Group 7.

Rank	Tenderer	Windows Sq. ft.	Unit price	Total	Rank	Doors Sq. ft.	Unit price	Total	Rank	Group total
1	Smith Bros. & [illegible]	4600	.50	[illegible]	5	1700	.25	[illegible]	4	[illegible]
2	F. R. Graham	"	1.00◆	[illegible]	2	"	[illegible]◆	[illegible]	3	[illegible]
4	Poole Constr. Co. Ltd.		1.35	6210.00	4	"	2.30	[illegible]	[illegible]	12000
3	Standard Constr. Co. Ltd.		.87	4002.00	[illegible]	"	[illegible]	[illegible]	[illegible]	[illegible]
5	Sanderson & Porter		[illegible]	4600.00	2		[illegible]	1100.00	[illegible]	[illegible]
6	D. G. Loomis & Sons	"	[illegible]	[illegible]	[illegible]		2.00	3400.00	[illegible]	[illegible]
7	Raymond Con. Pile Co. Ltd.	"	2.25	[illegible]	[illegible]		1.50	2550.00	5	[illegible]
	Engineer's Estimate	[illegible]	.38	[illegible]		1620	.15	[illegible]		[illegible]

Group 8.

Rank	Tenderer	Painting & tiling ex. structural steel Sq. yds.	Unit price	Total	Rank	Finishing concrete floors Sq. yds.	Unit price	Total	Rank	Group total
1	Smith Bros. & [illegible]	[illegible]	.15	1550.00	1	1800	.18	[illegible]	4	6434.[illegible]
2	F. R. Graham	"	.55	[illegible]	3	"	[illegible]	[illegible]		[illegible]
4	Poole Constr. Co. Ltd.		.50	4550.00	[illegible]	"	.125	2250.00	5	[illegible]
3	Standard Constr. Co. Ltd.	"	.60	5460.00	5	1800	[illegible]	[illegible]	3	[illegible]
5	Sanderson & Porter	"	[illegible]	[illegible]	5	1800	.430	7740.00	7	[illegible]
6	D. G. Loomis & Sons	"	[illegible]	5460.00	5	"	[illegible]	[illegible]	2	[illegible]
7	Raymond Con. Pile Co. Ltd.	"	.75	[illegible]	7	"	[illegible]	4050.00	[illegible]	[illegible]
	Engineer's Estimate	"	7½	[illegible]		800	.15	[illegible]		[illegible]

Group 9.

Rank	Tenderer	Lump Sums: [illegible] work	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	Group total	Remarks
1	Smith Bros. & [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	F. R. Graham	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
4	Poole Constr. Co. Ltd.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
3	Standard Constr. Co. Ltd.	3000.00	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible] Also offers to do work for cost plus $10,000.00
5	Sanderson & Porter	8500.00	[illegible]	[illegible]	4000.00	3500.00	[illegible]	[illegible]	included in estimate
6	D. G. Loomis & Sons	3500.00	[illegible]	[illegible]	3500.00	[illegible]	[illegible]	[illegible]	[illegible]
7	Raymond Con. Pile Co. Ltd.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2710.00	[illegible]	
	Engineer's Estimate	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Averages (unit prices):

Excavation	$1.57
Backfill	$0.63
2-4 Concrete	$21.33
1-2½-5 Concrete	$19.02
1-3-6 Concrete	$16.04
Reinforcing steel	$0.072
Brick	$12.25
Lumber	$99.17
Shingles	$12.10
Corrugated steel	$0.29
Tar and gravel roofing	$13.92
Lathing and plastering	$1.32
Composition floors	$7.42
Windows	$1.[illegible]
Doors	$1.45
Painting & tiling	$0.5[illegible]
Finishing concrete floors	[illegible]
Lump sums	[illegible]

Note:
- ◆ Not quoted in tender
- ▼ First item, hand excav.; second, mechanical
- ● First item, plain forms; second, circular
- ▲ First item, 24-gauge; second, 20-gauge

FIGURE 5

Summary of Tenders Received for Construction of Bienfait Plant.

For text reference see page 43

Fig. 6

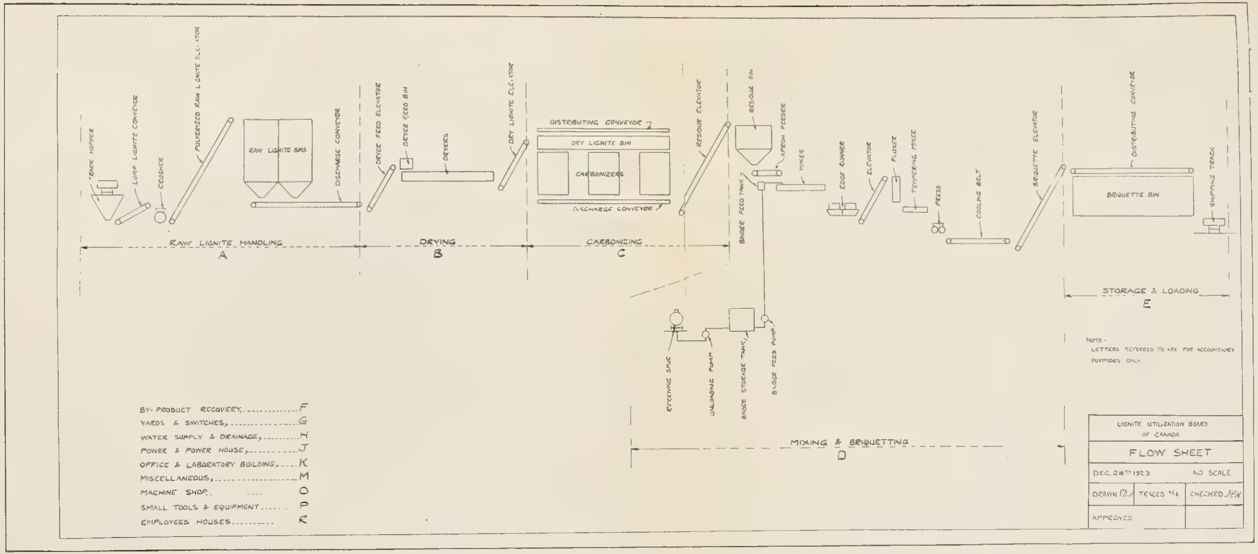


FIGURE 6

Flow Sheet of Board's Proc -

For text reference see pages 67 and 183

Fig. 7

SURVEY OF BRIQUETTING PLANTS

Visited on Investigatory Trip for Lignite Utilization Board Between November 11, 1918 and January 11, 1919.

	Plant reference Number appearing on briquettes shown in Plate I	12	10	13		8	11	4		3	1			9
1	[illegible]	Fuel Briquet Co	International Coal Products Corp	*Am. Briquet Co	†Lehigh Coal and Nav. Co	Scranton Anth. Briquet Co	Gamble Fuel Briquet Co	Va. Nav. Coal Co	Delparen Briquet Co	Std. Briquet Fuel Co	Pacific Coast Coal Co	Bankhead Col. Ltd	Stott Briquet Co	Berwind Fuel Co
2	Location,	Trenton, N. J.	Irvington, N. J.	Philadelphia, Pa	Lansford, Pa.	Dickson City, Pa.	Harrisburg, Pa.	Norfolk, Va.	Parrott., Va	Kansas City, Mo.	Renton, Wash.	Bankhead, Alta.	Superior, Wis.	Superior, Wis.
3	Builders,	Malcolmson.	Malcolmson.		Various.		Mashek.	Malcolmson.	Mashek.	Malcolmson.	Malcolmson.	Zwoyer.	Mashek.	Malcolmson.
4	Approx. capacity, tons per 24 hrs.,	200-250	Experimental	Experimental.	500.	1,000.	Part experimental.	1,000.	250-400.	700.	600.	1,000.	500.	900 600
5	Material handled,	Anthracite	"Semi-coke."	Anthracite	Anthracite.	Anthracite.	Anthracite.	Bituminous.	Semi-anth.	Semi-anth.	Lig. and bitumin.	Semi-anth	Anth. and bitumin.	Bituminous.
6	Drying by,	Direct heat.	None.	Direct heat.	Direct heat.	Direct heat.	Steam.	Direct heat	Steam.	Direct heat	Direct heat.	Direct heat.	Direct heat.	Direct heat.
7	Type of briquette,	Egg.	Barrel.	Pillow.	Egg.	Egg.	Pillow.	Cylindrical.	Pillow.	Cylindrical.	Cylindrical.	Pillow.	Pillow.	Cylindrical
8	Weight of briquette, ozs.,	1.	1½	2.	2.	2½.	1½.	16.	3.	11.	10.	2½.	2½.	13. 2½
9	Binder used,	Sulphite pitch.	Coal tar pitch.	"Hito".	Oil pitch.	Coal tar pitch.	Sulph. and oil pitch	Coal tar pitch.	Oil pitch.	Oil pitch.	Oil pitch.	Coal tar pitch.	Oil pitch.	Coal tar pitch. C. T. and oil pitch.
10	Condition of binder,	Liquid.	Hard or melted.	Emulsion.	Melted.	Melted.	Melted.	Hard.	Hard.	Melted.	Melted.	Melted.	Melted.	Hard. Melted.
11	Mixing ratio,	11.0±	9.0-11.0	8.7±	5.3±	10.0±	7.5±	6.4-7.5.	11.0±	7.5±	7.5±	8.7±	7.0±	7.5± 7.6±
12	Steam added to mixture?	Yes.	Yes.			No.	Yes.	Yes	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
13	Type of press,	Belgian roll.	Komarek.	Roll.	Roll.	Roll.	Roll.	Rutledge.	Roll.	Rutledge.	Rutledge.	Roll.	Roll.	Rutledge. Komarek.
14	Heat treatment,	In preparation.	Recarbonization.	Drying.	None.	None.	None.	None.	None.	None.	None.	None.	None.	None.
15	Cooling,	Air.	Air.	Air.	Sprays.	Immersion.	Air.	Air.	Air.	Air.	Sprays.	Air.	Air.	Air.

*Commercial plant building
†New 1,000-ton plant building.

FIGURE 7

For text reference see page 146

Fig. 8-a

The Tyler Standard Screen Scale

Cumulative Logarithmic Diagram of Screen Analysis on Sample of Carbonized Residue

Name (average of 14 samples) Date 1920

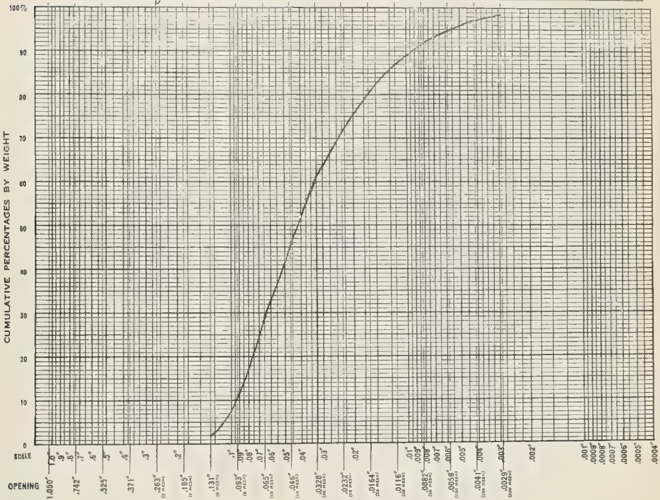


FIGURE 8-a

Screen Curve of Carbonized Residue in Ottawa

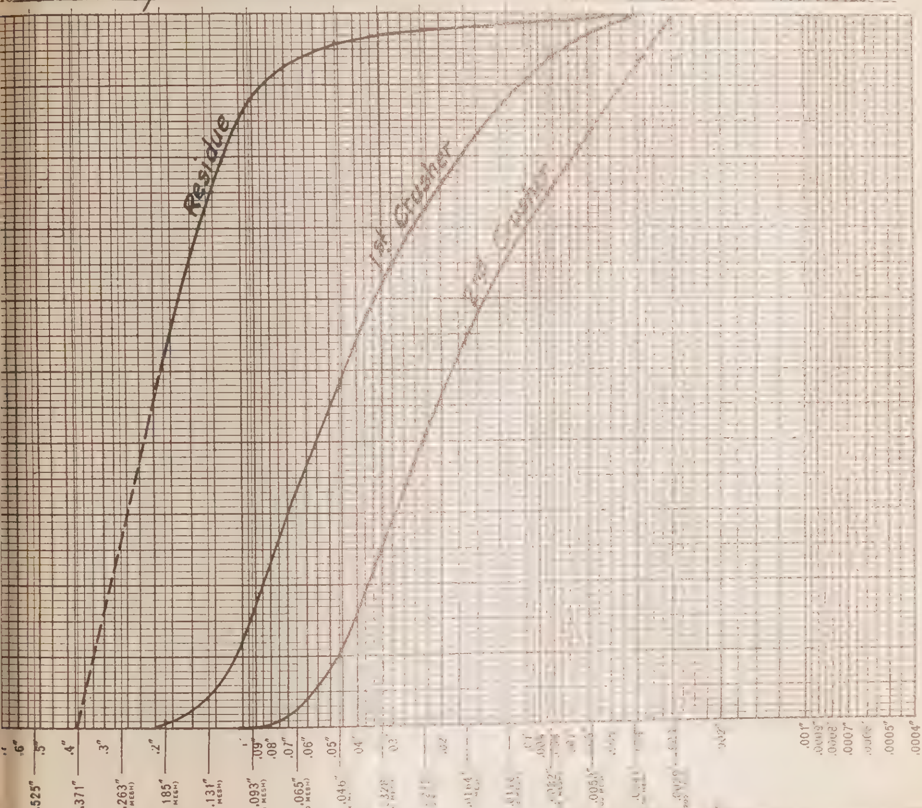
For text reference see page 70

Fig.8-b

The Tyler Standard Screen Scale

ulative Logarithmic Diagram of Screen Analysis on Sample of Carbonized Residue

ne Hebron Experiment Station Date Feb. 19 1923



	SCREEN SCALE RATIO 1.414				WEIGHTS			ASSAYS			CONTENTS			% of Total Contents		
	Openings		Mesh	Diameter Wire Inches	Sample Weights	Per Cent	Per Cent Cumulative Weights									
	Inches	Milli-meters						Wts	%	Cum %	Wts.	%	Cum %			
...	1.050	26.67		149	Residue											
...	742	18.85		135												
...	.525	13.33		.105												
...	.371	9.423		.092												
...	.263	6.680	3	.070												
...	.185	4.699	4	.065	988	52.4	52.4	17	1.0	1.0	—					
...	.131	3.327	6	.036	402	21.4	73.8	54	3.0	4.0	—					
...	.093	2.362	8	.032	267	14.2	88.0	175	9.8	13.8	—					
...	.065	1.651	10	.035	112	5.6	93.8	353	19.8	33.6	51	2.4	2.4			
...	.046	1.168	14	.025	44	2.3	96.1	251	14.0	47.6	150	7.5	9.9			
...	.0328	.833	20	.0172	18	1.0	97.1	276	15.4	63.0	322	15.1	25.0			
...	.0232	589	28	.0125	10	.5	97.6	155	8.8	71.8	323	15.1	40.1			
...	.0164	.417	35	.0122	7	.4	98.0	160	8.9	80.7	315	14.8	54.9			
...	.0116	.295	48	.0092	6	.3	98.3	139	7.8	86.5	222	10.4	65.3			
...	.0082	.208	65	.0072	6	.3	98.6	100	5.5	94.0	189	8.9	74.2			
...	.0058	147	100	.0042	6	.3	98.9	54	3.0	97.0	179	8.5	82.7			
...	.0041	.104	100	.0026	21	1.1	100.0	54	3.0	100.0	369	17.3	100.0			
...	.0029	.074	200	.0021												
...	.0029	.074	200	.0021												
				Totals,												

FIGURE 8-b

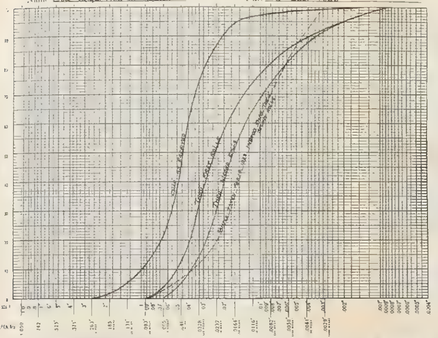
Screen Curve of Crushing results at Hebron, N. D., Feb. 19, 1923

For text reference see page 231

The Tyler Standard Screen Scale

Cumulative Logarithmic Diagram of Screen Analysis on Sample of ______

Name CHAR BRIQUETTED AT HEBRON   Date 8TH DEC. 1923



Indicate the Screen Crushed through and the Last Retaining Screen	SCREEN SCALE RATIO 1.414 Openings Inches	Openings Millimeters	Mesh	Diameter Wire Inches	WEIGHTS CHAR AS RECEIVED Sample Weights	Per Cent	Per Cent Cumulative Weights	ASSAYS CHAR Wt.	THRU FIRST ROLLS %	CUM. %	CONTENTS CHAR Wt.	THRU SECOND ROLLS %	CUM. %	% of Total Contents
	1.050	26.67		.148										
	.742	18.85		.135										
	.525	13.33		.105										
	.371	9.423		.092										
	.263	6.680	3	.070	5	10	10	97	.99	.99	.99	.92	.92	
	.185	4.699	4	.065										
	.131	3.327	6	.036										
	.093	2.362	8	.032										
	.065	1.651	10	.035	25.1	21.14	21.24	39.1	4.4	4.14	1.1	3.2	3.2	
	~~.046~~	~~1.168~~	20 ~~14~~	~~.025~~	261.8	52.96	74.12	139.5	27.90	32.06	7.6	14.32	14.54	
	~~.0328~~	~~.833~~	30 ~~20~~	~~.0172~~	88.8	17.72	91.93	120.9	24.18	56.24	135.5	27.10	41.64	
	~~.0232~~	~~.589~~	40 ~~28~~	~~.0125~~	20.9	4.00	95.93	54.1	10.96	67.20	67.3	13.44	55.10	
	~~.0164~~	~~.417~~	50 ~~35~~	~~.0122~~	7.9	1.58	96.96	41.4	8.32	75.52	58.8	11.76	66.86	
	~~.0116~~	~~.295~~	60 ~~48~~	~~.0092~~	3.4	.68	97.64	21.8	4.36	79.88	20.5	4.10	71.16	
	~~.0082~~	~~.208~~	70 ~~65~~	~~.0072~~	2.1	.42	98.06	14.8	2.96	82.84	17.6	3.52	75.08	
	~~.0058~~	~~.147~~	80 ~~100~~	~~.0042~~	.7	.14	98.20	3.6	.72	83.56	9.0	1.80	76.88	
	~~.0041~~	~~.104~~	100 ~~150~~	~~.0026~~	1.8	.36	98.56	0.5	2.10	85.66	23.5	4.70	81.58	
	.0029	.074	200	.0021	6.3	.66	99.22	87.0	14.10	99.76	32.6	6.50	88.06	
Pan	.0029	.074	~~200~~ 200	.0021	8.0	.78	100.00	35.7	7.14	100.00	39.8	7.96	100.00	
				Totals										

FIGURE 8-c

Screen Curve of Bienfait char briquetted at Hebron, Dec. 8th, 1923

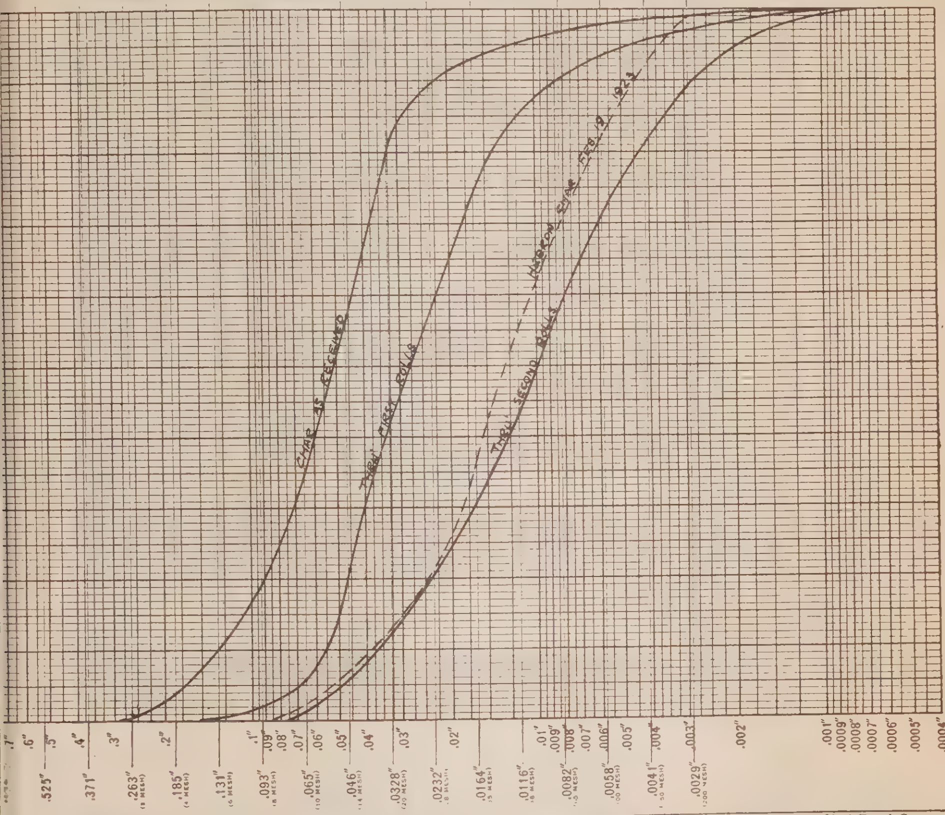
For text reference see page 234

Fig. 8-d

The Tyler Standard Screen Scale

...ulative Logarithmic Diagram of Screen Analysis on Sample of

...e CHAR BRIQUETTED AT HEBRON Date 12TH DEC. 1923



SCREEN SCALE RATIO 1.414				WEIGHTS			ASSAYS			CONTENTS			% of Total Contents		
Openings		Mesh	Diameter Wire Inches	CHAR AS RECEIVED Sample Weights	Per Cent	Per Cent Cumulative Weights	CHAR THRU FIRST ROLLS			CHAR THRU SECOND ROLLS					
Inches	Millimeters						Wt	%	cum %	Wt.	%	cum %			
1.050	26.67		.149												
.742	18.85		135												
.525	13.33		.105												
.371	9.423		.092												
.263	6.680	3	.070	4·2	.84	.84	·7	·14	·14	·2	·00	·00			
.185	4.699	4	.065												
.131	3.327	6	.036												
.093	2.362	8	.032												
.065	1.651	10	.035	167·6	33·52	34·36	29·0	5·80	5·94	6·3	1·26	1·26			
~~.046~~	~~1.168~~	20 ~~14~~	~~.025~~	227·0	45·40	79·76	176·2	35·24	41·18	55·2	11·04	12·30			
~~.0328~~	~~.833~~	30 ~~20~~	~~.0172~~	57·9	11·58	91·34	126·7	25·34	66·52	64·8	12·96	25·26			
~~.0232~~	~~.589~~	40 ~~28~~	~~.0125~~	13·7	2·74	94·08	60·0	12·00	78·52	44·5	8·90	34·16			
~~.0164~~	~~.417~~	50 ~~35~~	~~.0122~~	7·8	1·56	95·64	35·0	7·00	85·52	55·0	11·00	45·16			
~~.0116~~	~~.295~~	60 ~~48~~	~~.0092~~	4·3	·86	96·50	18·4	3·68	89·20	55·4	11·08	56·24			
~~.0082~~	~~.208~~	70 ~~65~~	~~.0072~~	3·3	·66	97·16	11·0	2·20	91·40	38·0	7·60	63·84			
~~.0058~~	~~.147~~	80 ~~100~~	~~.0042~~	1·7	·34	97·50	5·1	1·02	92·42	10·4	2·08	65·92			
~~.0041~~	~~.104~~	100 ~~150~~	~~.0026~~	1·9	·38	97·88	6·3	1·26	93·68	22·8	4·56	70·48			
.0029	.074	200	.0021	5·4	1·08	98·96	16·4	3·28	96·96	94·7	18·94	89·42			
.0029	.074	THRU 200	.0021	5·2	1·04	100·00	15·2	3·04	100·00	52·9	10·58	100·00			
			Totals,												

FIGURE 8-d

Screen Curve of Bienfait char briquetted at Hebron, Dec., 12th, 1923

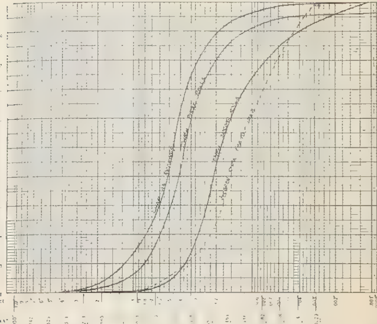
For text reference see page 234

Fig. 8-e

The Tyler Standard Screen Scale

Cumulative Logarithmic Diagram of Screen Analysis on Sample of

Name CHAR BRIQUETTED AT HEBRON Date 4th DEC 1923



Screen Scale Ratio 1.414: Openings in Inches	Openings in Millimeters	Mesh	Diameter Wire Inches	Char as received: Weights	Per cent	Per cent Cumulative Weights	Char thru first rolls: Wt	%	Cum %	Char thru second rolls: Wt	%	Cum %
[illegible]	26.67		[illegible]									
[illegible]	18.85		[illegible]									
[illegible]	13.33		[illegible]									
[illegible]	9.433		[illegible]									
[illegible]	6.680	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	4.009	4	[illegible]	[redacted]								
[illegible]	3.327	6	[illegible]									
[illegible]	2.362	8	[illegible]									
[illegible]	1.651	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~[illegible]~~	~~1.168~~	~~[illegible]~~	~~[illegible]~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~[illegible]~~	~~.833~~	~~[illegible]~~	~~[illegible]~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~[illegible]~~	~~.589~~	~~48~~	~~[illegible]~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~[illegible]~~	~~.417~~	~~[illegible]~~	~~[illegible]~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~[illegible]~~	~~.295~~	~~[illegible]~~	~~[illegible]~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~[illegible]~~	.208	70 [illegible]	~~[illegible]~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~[illegible]~~	~~.147~~	~~[illegible]~~	~~[illegible]~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
~~[illegible]~~	~~.104~~	~~[illegible]~~	~~[illegible]~~	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
.0029	.074	200	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	.074	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

FIGURE 8-e

Screen Curve of Bienfait char briquetted at Hebron, Dec. 14th, 19[illegible]

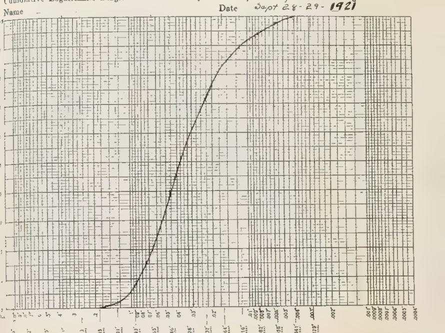
For text reference see page 234

Fig. 8f

The Tyler Standard Screen Scale

Cumulative Logarithmic Diagram of Screen Analysis on Sample of *Dryer Discharge Run D-5*

Name Date *Sept 28-29- 1921*



SCREEN SCALE RATIO 1.414

Openings Inches	Openings Millimeters	Mesh	Diameter Wire Inches	Sample Weights	Per Cent	Per Cent Cumulative Weights
1.050	26.67		.149			
.742	18.85		.135			
.525	13.33		.105			
.371	9.423		.092			
.263	6.680	3	.070			
.185	4.699	4	.065	7	.4	.4
.131	3.327	6	.036	34	1.7	2.1
.093	2.362	8	.032	136	6.8	8.9
.065	1.651	10	.035	247	12.4	21.3
.046	1.168	14	.025	374	18.7	40.0
.0328	.833	20	.0172	245	12.3	52.3
.0232	.589	28	.0125	276	13.8	71.1
.0164	.417	35	.0122	241	12.1	83.2
.0116	.295	48	.0092	140	7.0	90.2
.0082	.208	65	.0072	93	4.7	94.9
.0058	.147	100	.0042	56	2.8	97.7
.0041	.104	100	.0026	45	2.3	100.0
.0029	.074	200	.0021			
.0029	.074	200	.0021			
			Totals			

FIGURE 8-f

Screen Curve of Dryer Discharge Sept. 28th, 1921 Bienfait

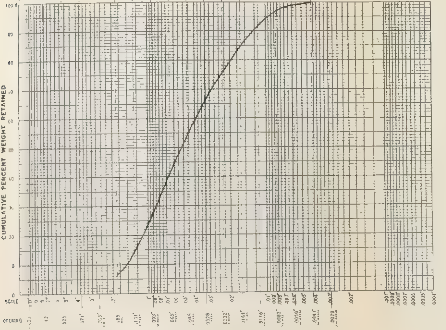
For text reference see page 189

Fig. 8-g

The Tyler Standard Screen Scale

Cumulative Logarithmic Diagram of Screen Analysis on Sample of Crusher (Fresh Coal.)

Name______________ Date______ Oct 6. 1922



SCREEN SCALE RATIO 1.414

Indicate the Screen Crushed through and also First Retaining Screen	Openings Inches	Openings Millimeters	Mesh	Diameter Wire Inches	Sample Weights gms	Per Cent	Per Cent Cumulative Weights
	1.050	26.67		.149			
	.742	18.85		.135			
	.525	13.33		.105			
	.371	9.423		.092			
	.263	6.680	3	.070			
	.185	4.699	4	.065	100	6.5	6.5
	.131	3.327	6	.036	127	8.3	14.8
	.093	2.362	8	.032	184	12.0	26.8
	.065	1.651	10	.035	244	15.9	42.7
	.046	1.168	14	.025	189	12.3	55.0
	.0328	.833	20	.0172	187	12.2	67.2
	.0232	.589	28	.0125	132	8.6	75.8
	.0164	.417	35	.0122	139	9.0	84.8
	.0116	.295	48	.0092	110	7.2	92.0
	.0082	.208	65	.0072	78	5.1	97.1
	.0058	.147	100	.0042	22	1.4	98.5
	.0041	.104	150	.0026	23	1.5	100.0
	.0029	.074	200	.0021			
Pan	.0029	.074	200	.0021			
				Total			

FIGURE 8-g

Screen Curve of Crusher Discharge Oct. 6th, 1922, Bienfait

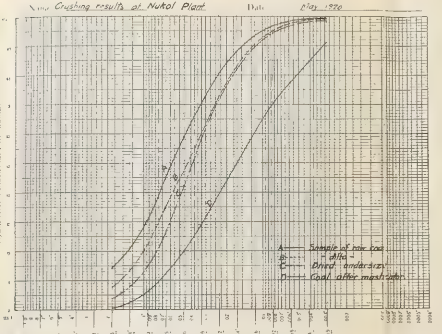
For text reference see page 188

Fig. 8-h

The Tyler Standard Screen Scale

Cumulative Logarithmic Diagram of Screen Analysis on Sample of *Anthracite Coal*

Name *Crushing results at Nukol Plant* Date *May 1920*



Indicate the Screen Crushed through and also the Retaining Screen

SCREEN SCALE RATIO 1.414				Raw Coal A			Dried Undersize			After mastication			Raw Coal B		
Openings Inches	Openings Milli-meters	Mesh	Diameter Wire Inches	Sample Weights	Per Cent	Per Cent Cumulative Weights									
1.050	26.67		.149												
.742	18.85		.135												
.525	13.33		.105												
.371	9.423		.092												
.263	6.680	3	.070	63 7	14.1	14.1	19.8	3.8	3.8	7.2	0.6	0.6	7.2	7.8	7.8
.166	4.699	4	.065	32 0	7.1	21.2	22.2	4.3	8.1	7.1	1.8	2.4	3.6	5.7	13.5
.131	3.327	6	.036	42 7	9.4	30.6	36.1	6.9	15.0	14.2	3.6	6.0	3.0	8.7	22.2
.093	2.362	8	.032	67 2	14.8	45.4	60.1	11.6	26.6	24.5	6.3	12.3	6.1	13.6	35.8
.065	1.651	10	.035	61 2	13.5	58.9	77.5	14.9	41.5	29.5	7.6	19.9	4.5	11.2	47.0
.046	1.168	14	.025	50 4	11.1	70.0	88.8	17.1	58.6	34.7	9.0	28.9	1.8	13.0	60.0
.0328	.833	20	.0172	46 3	10.2	80.2	67.7	13.0	71.6	40.2	10.4	39.2	3.4	12.9	72.9
.0232	.589	28	.0125	34 0	7.5	87.7	55.0	10.6	82.2	41.5	10.7	50.0	2.7	10.3	83.2
.0164	.417	35	.0122	27 0	6.0	93.7	39.3	7.6	89.8	40.0	10.4	60.4	.00	7.2	90.4
.0116	.295	48	.0092	4 5	3.2	96.9	26.5	5.1	94.9	38.9	10.1	70.5	9.6	4.7	95.1
.0082	.208	65	.0072	7 0	1.5	98.4	9.8	1.9	96.8	26.5	6.9	77.4	1.3	2.5	97.6
.0058	.147	100	.0042	4 2	0.9	99.3	7.0	1.3	98.1	26.8	6.9	84.3	5.7	1.4	99.0
.0041	.104	150	.0026	1 7	0.4	99.7	2.3	0.4	98.5	25.7	6.7	91.0	2.1	0.5	99.5
.0029	.074	200	.0021	0 9	0.2	99.9	1.0	0.2	98.7	34.0	8.8	99.8	1.5	0.4	99.9
.0029	.074	200	.0021	0 5	0.1	100.0	6.4	1.3	100.0	5.7	0.2	100.0	[illegible]	0.1	100.0
			Total	453.3	100.0		519.5	100.0		386.5	100.0		43.9	100.0	

FIGURE 8-h

Curve of Crushing results 1920 at Nukol Plant, Toronto

For text reference see page 226

Screen Analyses on Coals as Briquetted

Screen Size	Plunger Press				Roll Press											
	Bit & Lignite Renton, Wash		Semi-Anth Kansas City, Mo.		Anthracite Parrott, Va		Anthracite Trenton, N.J.		Carbon. Lignite Rolls 1 Ottawa, Ont		Carbon. Lignite Rolls 2 Ottawa, Ont.		Anthra[illegible] Dicks[illegible]		[illegible]racite [illegible] Pa	
	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	[illegible]	[illegible]	Cum %
+4	27.0	27.0	11.9	11.9	17.1	17.1	0.8	0.8	0.0	0.0	0.0	0.0	[illegible]	[illegible]	[illegible]	0.0
-4 +6	27.0	54.0	9.5	21.4	19.2	36.3	0.4	1.2	0.6	0.6	0.0	0.0	[illegible]	[illegible]	[illegible]	[illegible]
-6 +8	12.7	66.7	11.7	33.1	12.7	49.0	1.3	2.5	2.6	3.2	0.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-8 +10	11.8	78.5	15.8	48.9	13.3	62.3	10.3	12.8	12.7	15.9	3.8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-10 +14	7.5	86.0	14.0	62.9	10.9	73.2	11.9	24.7	15.5	31.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-14 +20	4.6	90.6	10.3	73.2	6.2	79.4	14.5	39.2	13.6	45.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-20 +28	3.8	94.4	9.6	82.8	5.4	84.8	17.3	56.5	12.3	57.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-28 +35	1.9	96.3	5.6	88.4	3.7	88.5	12.4	68.9	10.0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-35 +48	1.2	97.5	3.7	92.1	3.3	91.8	9.8	76.7	8.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-48 +65	0.8	98.3	2.2	94.3	2.2	94.0	7.9	86.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-65 +100	0.7	99.0	1.3	95.6	1.6	95.6	5.0	91.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-100 +150	0.5	99.5	1.2	96.8	1.4	97.0	3.8	95.4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
-150 +200	0.5	100.0	0.7	97.5	0.7	97.7	2.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
200	0.6	100.6	1.9	99.4	1.6	99.3	2.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Loss	-6	100.0	+6	100.0	+7	100.0	–	–	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

FIGURE 9

Screen Analyses of various coals as briquetted

For text reference see page 70

SCREEN ANALYSES OF RAW & CARBONIZED LIGNITE

Mesh	RUN OF 8/6/19				RUN OF 8/8/19				RUN OF 8/12/19				RUN OF 8/[illegible]/19			
	Raw		Residue		Raw		Residue		Raw		Residue		Raw		Residue	
	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %
On 3	0.75	0.75	0.10	0.10	–	–	–	–	0.5	0.5	0.0	0.0	–	–	–	–
4	4.20	4.95	2.35	2.45	2.0	2.0	1.2	1.2	4.9	5.4	2.0	2.0	3.2	3.2	[illegible]	2.7
6	18.80	23.75	12.15	14.60	12.2	14.2	6.5	7.7	20.0	25.4	12.4	14.4	[illegible]	[illegible]	[illegible]	12.3
8	22.65	46.40	22.45	37.05	20.5	34.7	17.8	25.5	23.8	49.2	23.2	37.6	[illegible]	[illegible]	[illegible]	35.5
10	19.45	65.85	23.25	60.30	23.6	58.3	22.5	48.0	18.5	67.7	24.4	62.0	17.8	[illegible]	[illegible]	56.2
14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
20	18.60	84.45	22.65	82.95	23.2	81.5	26.7	74.7	17.6	85.3	24.6	86.6	19.2	77.9	24.5	80.7
28	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
35	9.75	94.20	10.10	93.05	11.3	92.8	14.2	88.9	8.6	93.9	8.5	95.1	11.7	89.6	11.8	92.5
Ret. 35	5.80	100.00	6.95	100.00	7.2	100.00	11.1	100.00	6.1	100.00	4.9	100.0	10.4	[illegible]	[illegible]	[illegible]

Analysis by J.H.H. Nicolls. Carbonizing done by L.U.B. experimental carbonizer Raw lignite was dried and crushed with roll "corn" mill Refer [illegible] Stansfield's letter of Aug. 29th 1919

FIGURE 10

Screen Analyses of Raw and Carbonized Lignite (Ottawa results)

For text reference see page 70

Fig. 12

LIGNITE UTILIZATION BOARD OF CANADA. TESTS ON BRIQUETTES.															
	SMALL MIXER. Nov. 12. 1920.									LARGE MIXER. Oct. 23, 25, Nov. 1, 3. 1920.					
Batch No.	1	2	3	4	5	6	7	8		9	10	11	12	13	14
Material briquetted	Carbonized lignite. Nov 20th 1919 2 minute discharge.									Carbonized lignite, Nov 19th 1919 3 min disch					
Binder used	Coal Tar Pitch. 130° F M.P. dermined by ring & ball									Coal Tar Pitch. 130° F M.P by ring & ball					
Amount of coal lbs	6.625	6 625	6.625	6 625	6.625	6.625	6 625	6 625		58	61	56	56	60	60
Amount of binder lbs	0.862	0.862	0.862	0.862	0 862	0 862	0.862	0 862		7 66	7 84	7.84	8.38	9.03	8 98
Mixing ratio	13	13	13	13	13	13	13	13		13.2	12.8	14.0	14.9	15	14.9
Time in mixer before binder added	10 min	10	11	7	10	9	9	5		17	10	10	10	15	20
Temp of coal when binder added.	140° F	150°	160°	160°	155°	160°	150°	160°		160°	180°	180°	180°	180°	200°
Temp of binder degs Fah	340° F	320°	320°	320°	330°	330°	330°	290°		240°	310°	270°	220°	270°	280°
Steam pressure in boiler	40 lbs	50	40	40	40	45	40	40	Gas consumption Time for 10 c.f	3'-58"	3'-18"	4'-04"	4'-41"	4'-45"	4'-45"
Temp of mixing degs Fah	160	160	180	175	170	165	170	170		200	210	220	190	190	220
Time of mixing mins	15	30	45	60	15	30	45	60		33	25	27	30	30	28
Time cooled mins										5	5	12	5	5	7
Method of cooling										Shovelling on the floor					
Briquetting temp. degs Fah										180	190	170	170	165	180
Time in press secs	6	5	6	5	5+	5	5	5+		45	55	37	30	40	46
									Depth in press. ins	10-12	9	8	8-9	9-10	9-10
Speed of rolls before briquetting	11 rpm	11	11	11	11	11	11	11		11	11	11	11	11	11
Speed of rolls during briquetting	10 ±	10±	10±	10±	10 ±	10±	10±	10±		9+	10-	10-	10	9.5	9+
Method of catching discharge	Briquettes caught on a shovel to break the fall									Fall broken by a shovel					
Wt of screened briquettes lbs	5.41	6 02	6 03	6 07	7 14	7 64	7 24	7.62		47	54	47 5	47	53 5	56 5
Wt of screenings. lbs.	1.59	1 51	1 58	1 40	1 64	1 49	1 56	1.60		12	14	12	11.5	7.5	10
Total recovery %	93 8	100 6	101 5	100.0	97.2	101.0	97.4	102.0		90.0	99.0	93.0	91.0	88.0	96.0
Fines. % of recovery	22.6	20.0	20.8	16 5	18.7	16.3	17.7	17 3		20.3	20.6	20.2	19 7	12 3	15 0
Density of briquettes.	1.237	1 236	1 233	1 233	1 187	1 202	1 262	1 210		—	—	—	1.255	1.195	1.208

Note- To batches Nos. 5.6.7 8, 155 lbs. screenings were added

REMARKS.

All batches were briquetted in a Mashek Roll Press
Batches 1-8 were mixed in a small bread mixer. blades at 28 & 60 r p m resp
The idea that a variable time factor in mixing has an important bearing on the strength of briquette is not borne out
Batches 5 8 The addition of screenings does not help toward harder briquettes
Batches 9-14 were mixed in a larger gas heated cylindrical paddle mixer

PRELIMINARY OBSERVATIONS

No 1. Stands drop Not crumbly Good briquette
No 2 Not so strong as No 1 Some stand drop Clean break not crumbly Good
No 3 Same as No 2 but slightly crumbly
No 4 Will not stand drop Slightly crumbly
No 5 -do- -do- Crumbly Only fair
No 6 Some stand drop All fractures clean Good
No 7 Stands drop Good strong briquette
No 8. Will not stand drop, but break is clean and not crumbly
No 9 Failed in drop test Crumbly
No 10 -do- -do- Not crumbly Good average briquette
No 11. -do- -do- -do- -do- -do-
No 12 Stands drop. Fracture clean Not crumbly Very fair
No 13 Some stand drop Crumbly Not so good as No 12
No 14 -do- -do- Fracture clean Not crumbly
Note- These observations are more or less borne out by the densities

DROP TEST - 6 Briquettes dropped 10' to concrete floor

Batch No	1	2	3	4	5	6	7	8
Wt of briquettes, gms	285	286	261	271	276	267	275	265
Wt retained on ½ screen, gms	280	280	258	262	267	262	273	258
Number of briquettes broken	2	1	1	3	3	1	1	2
Number of briquettes cracked	0	1	1	0	0	1	0	0
Number of briquettes chipped	1	1	2	2	1	2	1	0
Loss. %.	1.7	2.1	1.2	3.3	3.3	1.9	0.7	2.6

FIGURE 12
Briquetting Results (From L. U. B. Data sheet LVI)
For text reference see page 71

Briquetting Results - Lignite Utilization Board

A.D.S.L = air dried sulphite liquor fines: C-1st = coarse first: C M = passed through coffee mill once: CM-2 = passed through coffee mill twice. C T P-140 = coal tar pitch, 140°F. m.p: F-1st = fines first: F-122 etc = fines from Series No 122 etc.: G T = gas tar: H W P-130 = hard wood pitch 130°F. m.p: H W T = hard wood tar. LT-50% = lignite tar, 50% water: LT. 33% = lignite tar, 67% water: M.R = mixing ratio: O P-172 = oil pitch 172°F m.p: Paste 3/23 = flour paste, 3 in 23: R-1 = passed through rolls once: R-2 = passed through rolls twice: S.L-50% = commercial sulphite liquor, 50% solids: S L-1/4 etc = commercial sulphite liquor diluted so as to contain 1 part solids to 3 parts water, etc

Series No. 100 is dried lignite
Quality grading is up from "P" through P+ F- F, F+ G- to G

Series No.	Residue: Date mfd.	Residue: Size	Residue: % Vol's	Binder: First M.R	Binder: First Kind	Binder: Second M.R	Binder: Second Kind	Binder: Third M.R	Binder: Third Kind	Binder: Final M.R Solids only	Quality: From press	Quality: Handling	Quality: Burning	Quality: General, summarized
96	Anth	R-1	4-5	7	CTP-190°					7	G			F-G [illegible]
98	"	"	"	7	" 140					7	G			[illegible]
100	230°	C.M	38-40	20	" 190						G			P
102	8/8/19	"	17	10	H.W.P-130	5	H W T			15				" "
104	"	"	7.6	15	C T P-140					15	P	N G		" "
105	"	"	7.6	12	" 190	4	"			16	P	N.G		" "
107	"	"	7.6	20	" 140					20	P	P		" "
108	"	"	7.6	15	" 190		Steam			15	P	P		" "
109	"	C.M-2	7.6	20	" 140					20	P	P		" "
110	"	"	7.6	25	" "					25	F	F	P	" "
111	"	R-2	7.6	25	S.L -50%					12-13	G	G	G	G but not waterproof
112	"	"	7.6	25	S.L.- 1/4	10	C T P-140°			16-17	F	F	F	F; quite smoky
113	"	"	7.6	25	" "	12	" "			18-19	G	G	F	F, very "
114	"	"	7.6	20	" "	10	" "			15-16	F	F	F	F, smoky
115	"	"	7.6	20	" 1/8	10	" "	4	L T-50%	14-15	F	G	F	F-G, smoky
116	"	"	7.6	25	Water	15	" "			15	F+	F	F	F, very smoky
117	"	F-1st	7.6	12	C T P-190	20-25	Water	4	" "	14	F+	G	F	[illegible]
118	"	C-1st	7.6	25	Water	4	L T-50%	12	C T P-140	14	F+	G	F	" " "
119	"	R-2	7.6	25	"	4	" "	12	" "	14	P	P	F	" " "
120	"	"	7.6	20	"	11	C T P-140	2	H.W.T	13	F	F-	F-	" " "
121	"	"	7.6	20	S.L - 1/8	10	" "	5	L T 33%	14	F+	G	F	" quite "
121 A	-	F-121	-	25-30	" 1/16					-	F-G	G	F+	" " "
121 B	-	"	-	25-35	Water					-	G	G	F+	" " "
122	8/11/19	R-2	7.6	23	Paste, 3/23	10	" "			13	P	P	P	P, smoky
122 B	-	F-122	-	25-30	Water					13	F-G	G	F	F; "
123	8/11/19	R-2	7.6	26	Paste: 1/20	10	" "			11	P	P	P	P, "
124	"	"	7.6	10	S.L- 1/4	15	" Hite	5	" "	7	P	F	F	F; "
125	"	"	7.6	25	" 1/8	10	" 140	2	" "	14	P	P+	F-	F-; "
125 B	-	F-125	-	25-30	Water					14	F	F-	F	F+; "
126	8/11/19	R-2	7.6	25	S.L- 1/4	8	" "			14-15	F	F+	F+	F-G; "
127	"	"	7.6	25	" "	5	" "	5	" "	12-13	F	G	G	G, little smoke
128	"	"	7.6	20	" "	4	" "	6	" "	11	P	F	F+	F+, " "
129	"	"	7.6	23	" 1/8	4	" "	6	" "	9	P	P	F	P, smoky
130	"	"	7.6	20	" 1/4	5	" "	5	" "	12	P	P	F	F: some smoke
131	"	"	7.6	15	" "	5	" "	5	" "	10-11	P	P	P	P, " "
132	8/25/19	"	11-12	25	" 50%					12-13	F	F-	G	F. poor mixing
132 B	-	F-132	-	20	" 1/8					-	F+	F	G	F-G when dry
133	8/25/19	R-2	11-12	25	" 50%					-	G	G	G	G not waterproof
134	"	"	11-12	25	" 1/4	6	" "	4	" "	13-14	P	P	F+	F, little smoke
135	"	"	11-12	25	" "	6	O.P-172	4	" "	14	G	G	G-	G, smoke burns
136	"	"	11-12	20	" "	6	" - 201	4	" "	12-13	P	F-	F+	F, " "
138	"	"	11-12	20	" "	7	C.T.P-140	3	" "	13	F	P	G	F
139 A	-	F-138	-	10	Water					-	F+	G	F+	G-
140	8/11/19	-	7.6	20	S.L - 1/4	7	" "	3	" "	13	G-	G-	G	G
141	A.D.S.L.	-	-	25	" "	8	" "	4	" "	-	P	P	-	P
142	8/25/19	R-2	11.5	20	" 50%	3	G T			13	F+	F	G	F+
143	"	"	"	20	" "	5	Water			-				N.G.: too wet
145	"	"	"	25	" 1/4	6	C T P-140	3	G T	15	F+	G	G	G
146	"	"	"	20	" 50%					10	F	F	G	F+; not waterproof
147	-	F-146	-			5	G T			-	F-	P	F+	P

FIGURE 13

Briquetting Results (From L. U. B. data sheet XLVI)

For text reference see page 71

Fig. 14

BRIQUETTING RESULTS - LIGNITE UTILIZATION BOARD

Tables I to V with Carbonized Lignite Small mixer & roll press

CARBON[illegible] NOV [illegible] 919

Note No. I. - Briquettes made with notable amounts of soft tar have good surface and stand drop test but can be broken in the fingers, they harden with age

Volatile matter about 6%, passed twice through small rolls GOOD commercial briquettes classed as A and subdivided +A A-A. POOR commercial briquettes classed as B and subdivided +B B-B [illegible] commercial briquettes classed as C and subdivided +C C-C FAILURES classed as D Drop test series [illegible] ted of a 10ft drop onto a wooden floor with the Briquette falling flat Subsequent to series [illegible] was a 6 ft drop onto a cement floor with the Briquette falling flat TABLE No. I [illegible] Tar Pitch M.Pt 140°F. TABLE No II Series Nos 160 to 169. Coal Tar Pitch [illegible] TABLE No III Series Nos 170 to 180 inclusive & 182 Sun Coy. Hydrolene M.Pt 160°F Toledo [illegible] TABLE No IV [illegible] to 187 inclusive Imperial Oil Co. Asphalts of different Melting Points TABLE No V Series 201 [illegible] with variations The Hite Mixtures in practically all cases produced Briquettes having a smooth [illegible] but which could be broken in the hands C.T.P = Coal Tar Pitch W.G [illegible] L.T [illegible]
A = Asphalt : H = Hydrolene ' M.R. = Mixing Ratio : L T 50% = Lignite Tar [illegible] sulphite liquor diluted so as to contain 1 part solids to 3 parts water [illegible] W. = Water
G.T = Gas Tar ' L.A. = Lignite Asphalt : T.P. = Toledo Pitch. [illegible]

Series Number	BINDER FIRST M.R.	FIRST KIND	SECOND M.R.	SECOND KIND	THIRD M.R.	THIRD KIND	QUALITY Shot Solids	[illegible]ling	[illegible]ing	Whtn Brq.	Test	General summarized
150	25	Water	15	CTP	-	-	15	F	F	-	Pass.	+B ; Slow Speed; See Note I
151	25	"	15	"	-	-	15	F	F	-	Pass.	-A ; Fast " , "
152	25	"	10	"	-	-	10	P	P	-	Fail	+C, 10½ R.P.M. ;
153	25	"	12	"	-	-	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
154	25	"	10	"	2	L.T	12	F	F	[illegible]	[illegible]	[illegible]
155	25	"	10	"	5	L.T	15	N.G	P	[illegible]	[illegible]	[illegible]
156	25	"	2	CaO	12	CTP	14	N.G	P	[illegible]	[illegible]	[illegible]
157	25	"	2	C	12	"	14	P	P	[illegible]	[illegible]	[illegible]
158	25	"	2	WG	12	"	14	P	P	150°	Fail	-B : "
159	25	"	1	$MgCl_2$	12	"	13	F	F	150°	Fail	+B. "
160	25	"	15	C.T.P	-	-	15	P	P	170°	Fail	-C. Mixed 10 min. at 200°F.
161	25	"	15	"	-	-	15	P	P	200°	Fail	+C, " "
162	25	"	15	"	-	-	15	F	F	200°	Pass	-B; " 20 min " 212°F
163	25	"	12	"	3	L T	15	G	F	200°	Pass	+B, " "
164	25	"	12	"	-	-	12	P	F	200°	Fail	-C, " "
165	25	"	15	"	1	C	16	P	F	200°	Pass	+C, " "
166	25	"	15	"	½	$MgCl_2$	15.5	F	F	200°	Fail	+C,
167	15	CTP	-	-	-	-	15	G	G	200°	Pass	+B;
168	12	"	-	-	-	-	12	P	F	200°	Fail	-C, "
169	15	"	25	Water	-	-	15	F	F	200°	Pass	C ; W. added just [illegible]
170	-	-	15	H	-	-	15	G	G	200°	Pass	A, G. Briquette; little smoky
171	25	Water	15	"	-	-	15	G	G	200°	Pass	+B; G. " , rough surface
172	-	-	12	"	-	-	12	G	G	200°	Pass	+B; G. " "
173	9	Water	10	"	-	-	10	F	F	190°	Fail	C ; Not sufficient binder
174	-	-	8	"	8	C.T.P 190°	13	-	-	200°	-	D, No briquettes
175	10	Water	8	"	5	" 190°	13	-	-	200°	-	D, " "
176	10	"	7	"	7	C.T.P 140°	14	-	-	180°	-	D. " "
177	-	-	7	"	7	T.P	14	G	G	180°	Pass	B, Rg. surface; little smoky
178	2	L T 50%	4	"	10	T P	15	F	P	180°	Pass	+C; Soft breaks in fire
179	15	S L 50%	7	"	-	-	14	P	P	190°	Fail.	+C; Poor surface
180	25	" ¼	7	"	-	-	13-14	P	P	190°	Fail	C, " "
182	15	" 50%	7	T P	-	-	14-15	G.	P	190°	Pass	B. Breaks in fire
181	15	A 223°F	-	-	-	-	15	P	P	180°	Fail	D;
183	15	A 172°F	-	-	-	-	15	G	G	170°	Pass	+C, Rgh surface otherw. good
184	15	A 210°F	-	-	-	-	15	G.	G.	190°	Pass	+C;
185	11	S & H_2O	14	S.L 50%	7	A 120°F	14	G	G	160°	Pass	-B; p. surf. W & S.L mixed together
186	11	"	14	"	7	A 265°F	14	G	F	190°	Pass	C, g. surf but crumbly
187	11	"	14	"	7	A. 121°F	14	G	G	160°	Pass	B;
201	2	Flour	24	Water	6	A 160°F	8	P	P	150°	Fail	-C, No emulsion, Brigs N.G
202	2	"	24	"	6	"	8	-	-	120°	-	D: " No Briqts
203	35	of above mixture	-	-	-	-	9	P	P	120°	Fail	-C; P Briquettes
204	53	" "	-	-	-	-	13	P	P	120°	Fail	C; " "
205	4	Flour	48	Water	8	Gas Tar	12	P	P	100°	Fail	C; G. Emul: Briq. Soft & crumbly
206	4	"	48	"	8	G.T 4.A. 160°	12	F	P	100°	Pass	+C [illegible]
207	1½	"	17	"	2¾	G.T 8.A 160°	12	F	P	175°	Pass	C. Crumbly
208	1½	"	17	"	2¾	G T 8-C.T.P. 140°	12	F	P	175°	Fail	C "
209	4	"	48	"	8	C.T.P. 140°	12	F	F	175°	Fail	C Surface G breaks in hand.
210	2	"	25	"	10	C T P	12	F	P	160°	Fail	C: " "
211	2½	"	25	"	5	Liq A	13½	F	P	180°	Fail	C Mixed with A. 160° M.R. 6
212	2½	"	25	"	5	A 135°	13½	P	P	150°	Fail	-C " "

FIGURE 14

Briquetting Results (from L. U. B. data sheet XLVII)

For text reference see page 71

Fig. 15

Exact Copy of Estimate prepared in 1917 by Fuel Committee of Research Council

BRIQUETTING PLANT

Capital Cost [illegible]	Annual Output 15,000 tons	Annual Output 30,000 tons
	$	$
1 Material [illegible]	2[illegible],000	20,000
2 Briquetting Press	15,000	15,000
(3) Waterproofing Oven	15,000	15,000
(4) Dryer and Carbonizing Kilns	28,000	56,000
(5) Power Plant, Motors and Wiring	[illegible]	[illegible]
(6) Conveyors, Mixers, Track Hoppers, Bins, Storage, etc.	40,000	45,000
(7) Fuel Gas and Pitch Recovery Plant	23,000	23,000
(8) Shop Tools, Laboratory, etc	10,000	10,000
(9) Labour on all above	50,000	55,000
(10) Engineering and Travelling expenses, Freight and Insurance	27,000	30,000
Total	260,000	301,[illegible]
(11) 15% for Engineering and Contracting	[illegible]	[illegible]
Grand Total	299,000	346,150
(12) Interest on above—6 months at 6%	8,970	10,384
(13) Expenses of operation for 6 months of adjustment	10,000	10,000
Total	317,970	366,534
Fixed Charges Interest = 6%; Depreciation = 10%; Repairs = 4%;—Total = 20%	63,594	73,307
Per ton of output	4.21	2.44

Col. 1: Estimate prepared by Research Council — 1917, rearranged to suit headings in Col. 2. Figs. in parentheses, thus (8), are reference nos. to original estimate. Ref. No.	Item	Cost	Col. 2: Contract prices and estimated prices for present undertaking of L. U. B. Prepared in May 1920. Item	Cost	Col. 3: Estimated prices for exactly similar equipment had it been obtained in first quarter of 1917.	Col. 4: Remarks on col. No. 3. The below quoted, average percentages were obtained from various engg. sources and are believed to be conservative
(1)(9)(6)	Labor and Materials on bldgs including bins	$90,000	Yard switches, sidings, Buildings	$195,000	Buildings $11[illegible] Front [illegible] 11,500 Yard, Switches, etc 6,000	Complete [illegible] estimate based on figures and prices from Dept. of Labour, Ottawa.
2	Briquetting press	[illegible]	[illegible] Mixer	[illegible]	16,7[illegible]	Based [illegible] since 1917
(3)	Waterproofing oven	15,000	Not contemplated now			
(4)	Dryers and Carbonizers	50,000	Dryers 30,000) Carboniser [illegible])	[illegible]	a) Dryers $32,000) b) [illegible] 2[illegible]) [illegible]	a) Contractor's quotation. b) Estd. on 60% advance [illegible] 1917
(5)	Power Plant	[illegible]	[illegible]	[illegible]	4[illegible]	Based on [illegible] since 1917
(6)	Conveyors	30,000	Track Hopper, Conveyors	52,000	29,000	Based on average advance of 80% since 1917
(7)	By-product Plant	23,000	Binder storage and gas [illegible]	10,[illegible]	[illegible]	Based [illegible] since 1917
(8)	Shop tools and Lab	[illegible]	[illegible]	[illegible]	4,500	Based on average advance of [illegible] since 1917
10	Engineering	[illegible]	[illegible] engineering Actual up to March 31st $41,000 — Estd for next 11 months at 2,500, = $27,500	[illegible]	[illegible]	Based on advance of 25% since 1917
(11)(12)	Contracting and Int.	55,000			22,000	Based on advance of 30% since 1917.
(13)	Working capital	10,000	Working capital 8 months at 4,000	32,000	18,500	Based on advance of 70%
			Totals	552,500	304,200	
			Contingencies 8-½%	47,500	Conting. 8-½% 30,957	
	Total	$388,000	Final Totals	600,000	$305,157	
			Housing	75,000		
			Total	$675,000		

FIGURE 15

Digest of Estimates on Plant Expenditure

For text reference see page 83

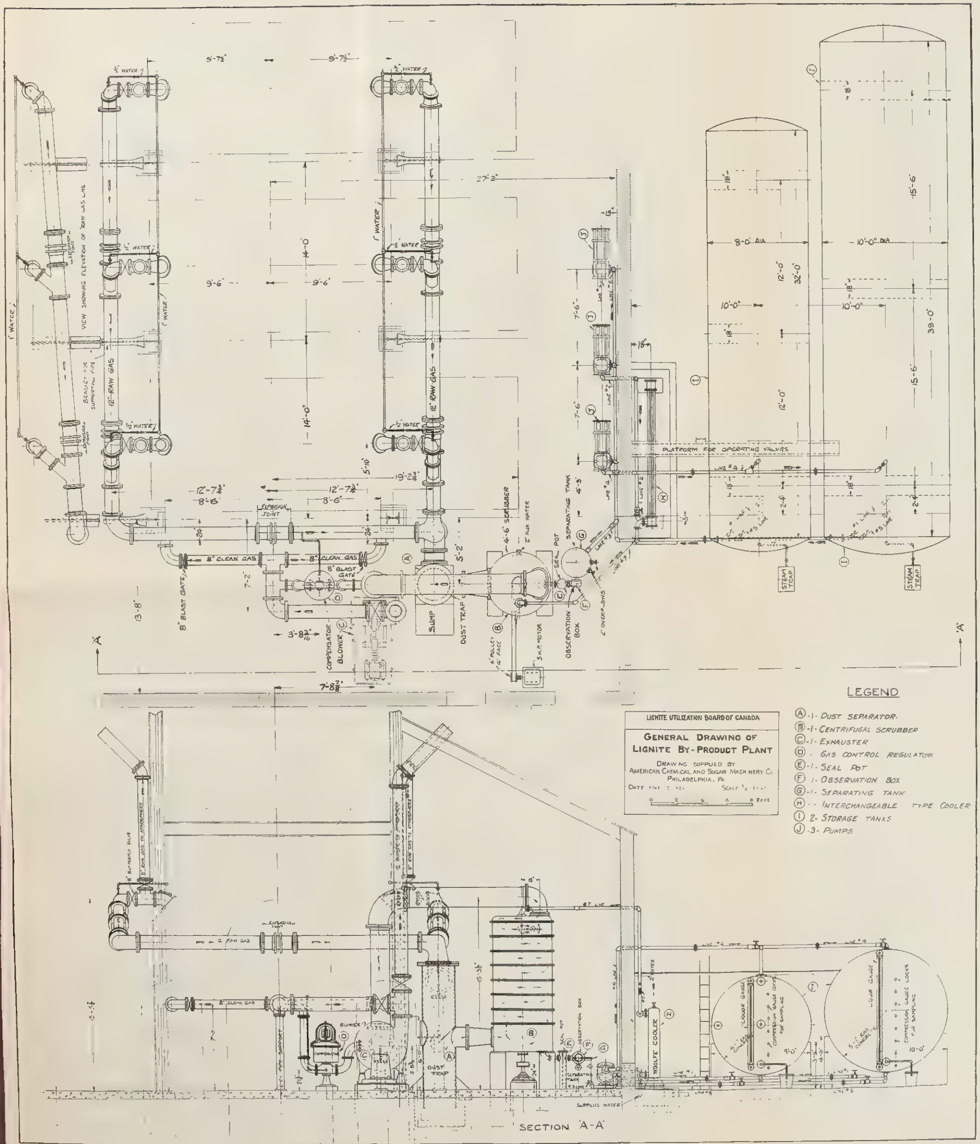


FIGURE 17-a
Layout of Gas System as constructed 1921
For text reference see page 184

Fig. 17-b

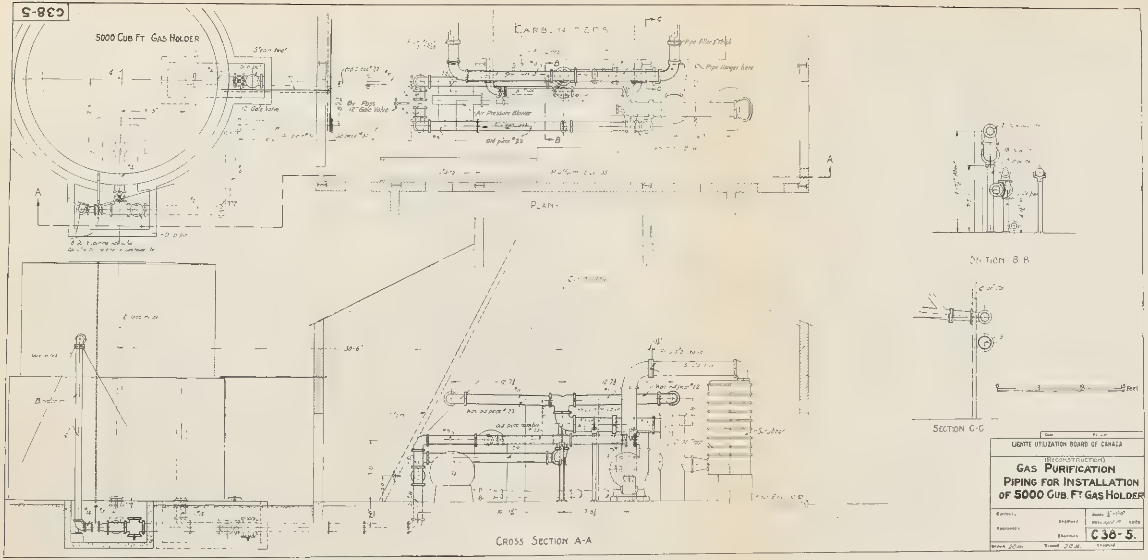


FIGURE 17b

Revised layout of Gas System Bienfait Plant 1922

For text reference see page 190

Fig. 18

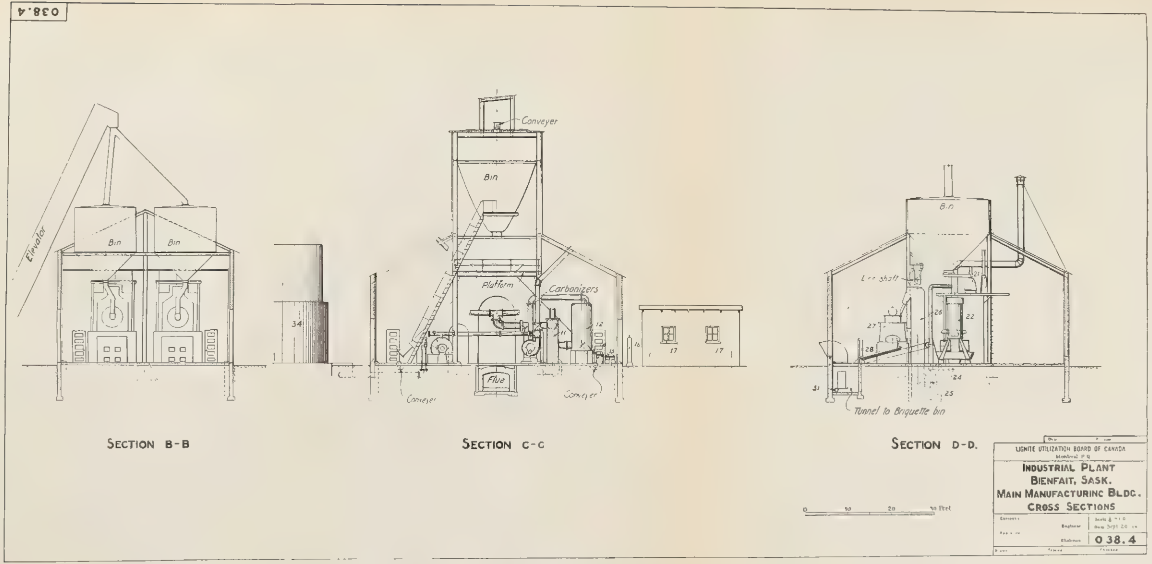


FIGURE 18
Sections of Main Manufacturing Buildings Bienfait Plant
For text reference see pages 76 and 186

Fig. 19

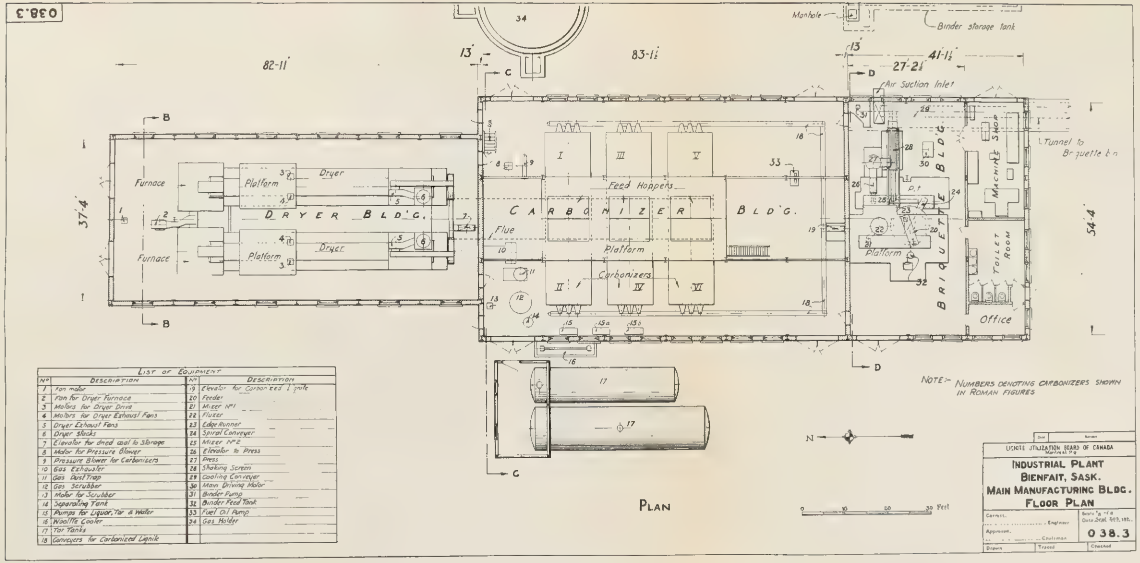


FIGURE 19
Plan view of Main Manufacturing Buildings Bienfait Plant
For text reference see pages 76, 184 and 186

Fig. 20

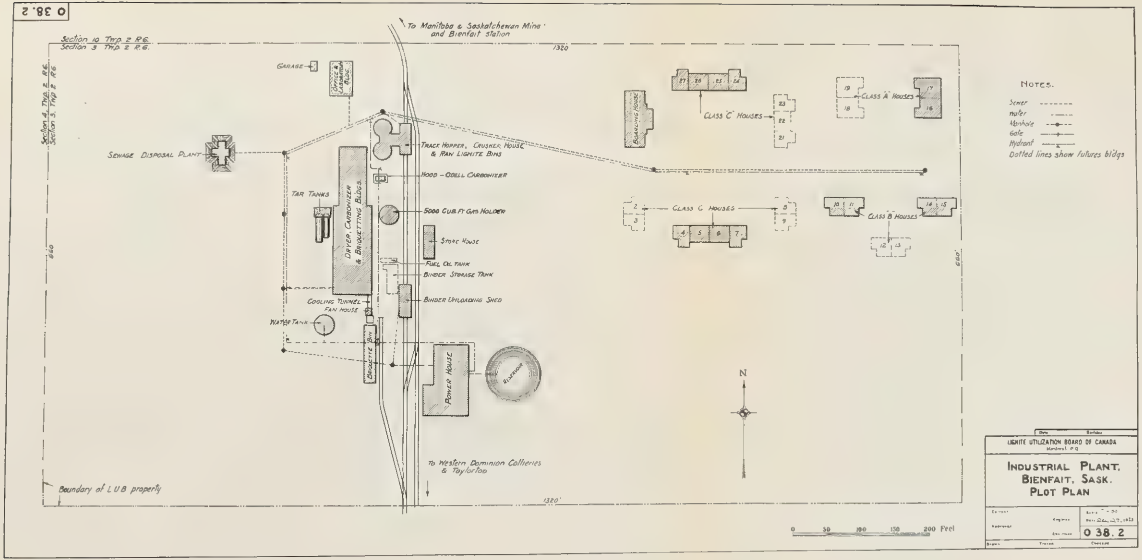


FIGURE 20
General Plot Plan Bienfait Plant
For text reference see page 62

Fig. 21

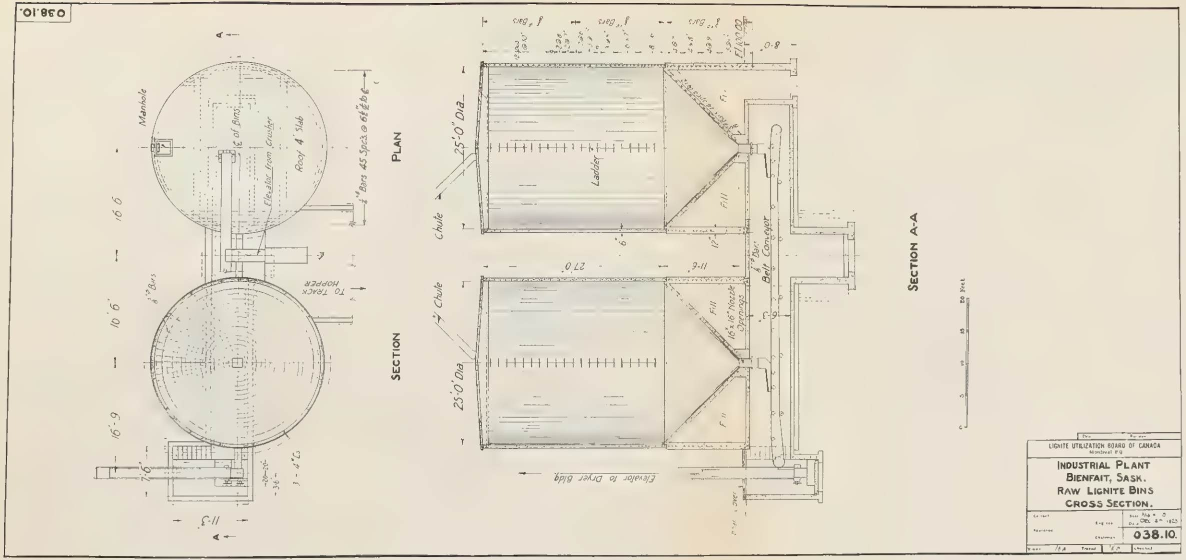


FIGURE 21
Raw Lignite Bins
For text reference see page 183

Fig. 22

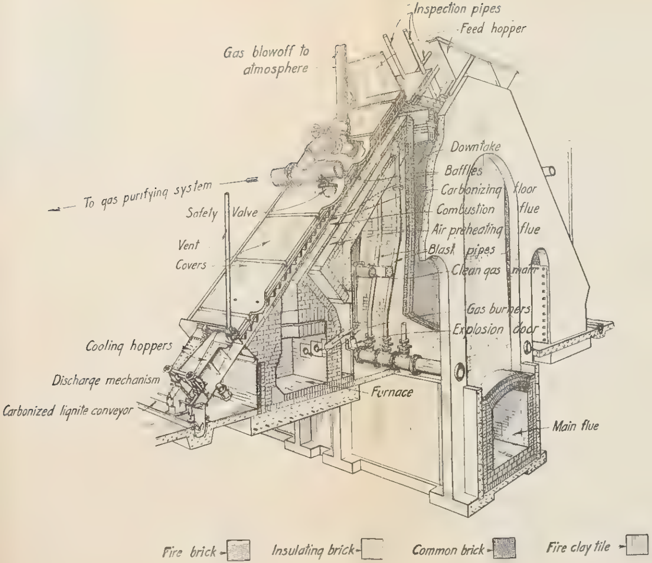


FIGURE 22
Sectional Perspective view of Stansfield Carbonizer Bienfait
For text reference see page 184

Fig. 23

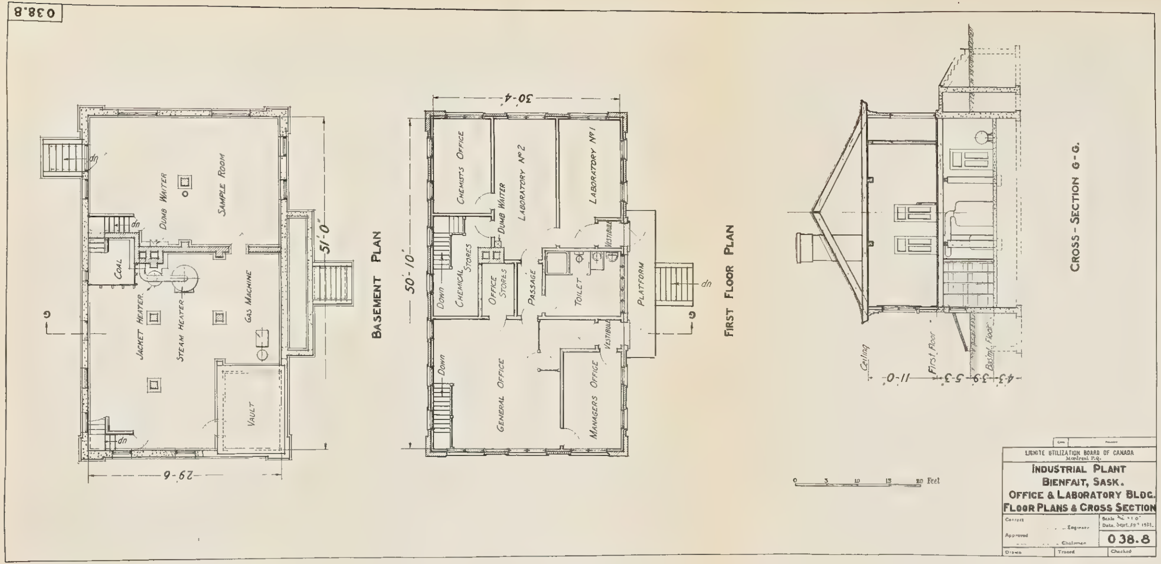


FIGURE 23

Office Building and Laboratories Bienfait Plant

For text reference see page 187

Fig. 24

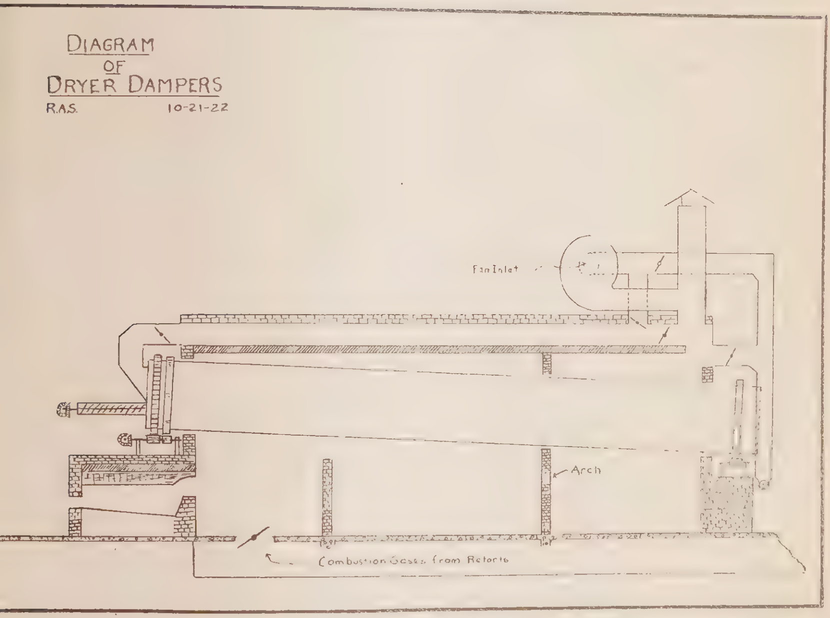


FIGURE 24

Section of Dryer showing position of dampers Bienfait Plant

For text reference see pages 183 and 189

Fig. 25

Fig. 25

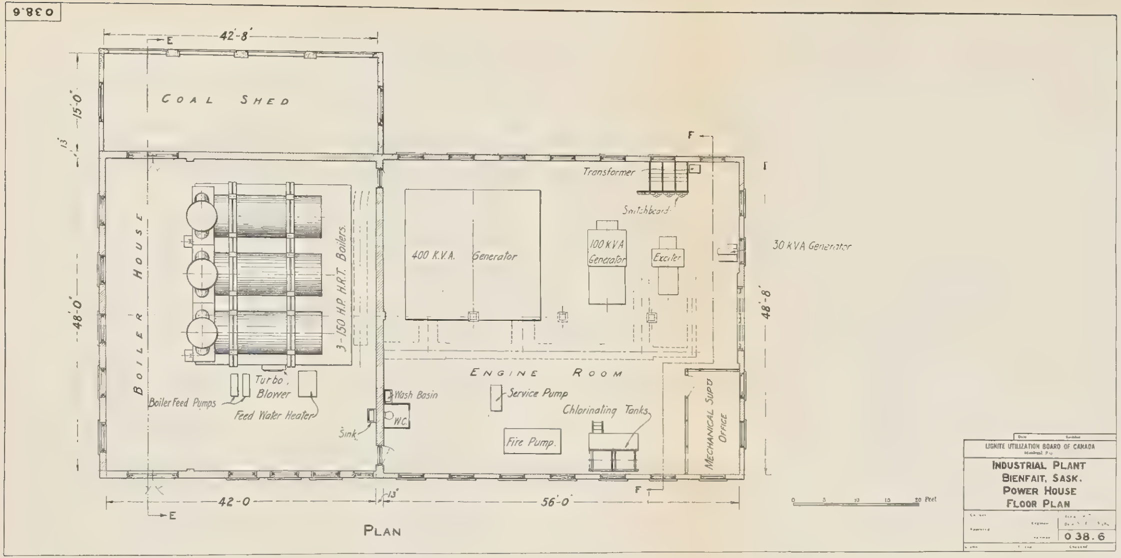


FIGURE 25
Power House Floor Plan
For text reference see page 187

Fig. 26

Fig. 26

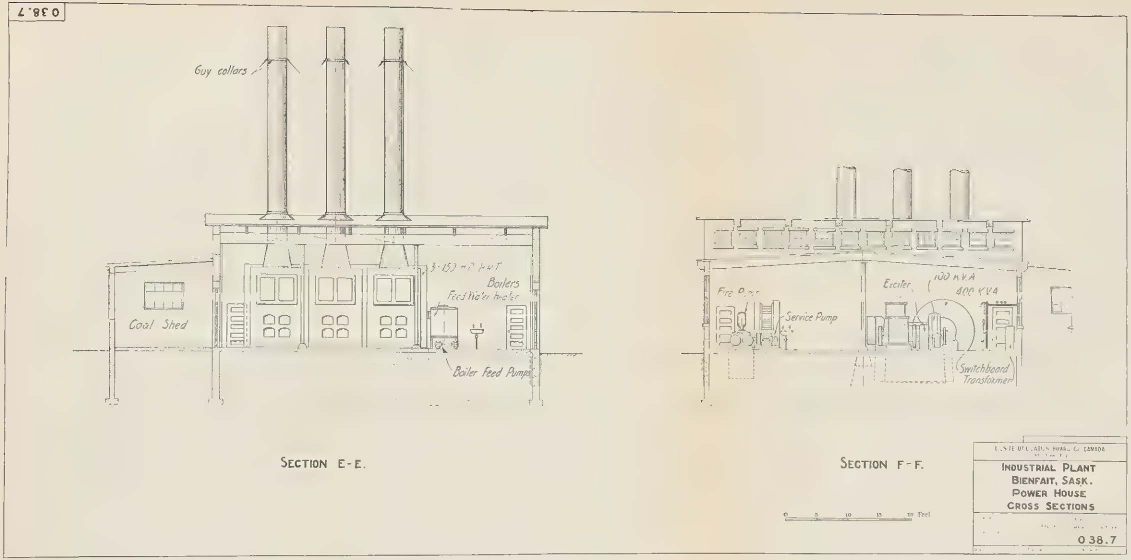


FIGURE 26
Cross Section of Power House
For text reference see page 187

Fig. 27

Fig. 27

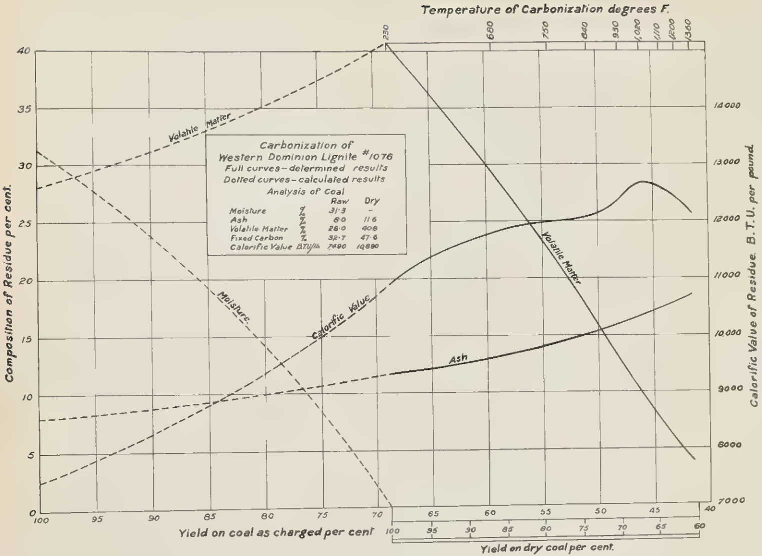


FIGURE 27
Carbonization Curves of Western Dominion Lignite
For text reference see page 166

Fig. 28

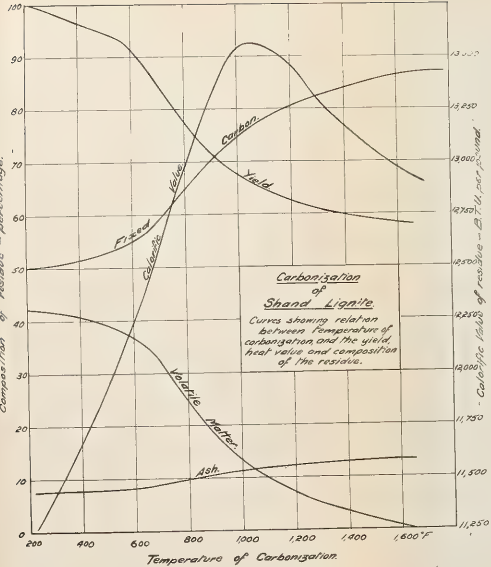


FIGURE 28

Carbonization Curves of Shand Lignite

For text reference see page 163

Fig. 29

Fig. 29

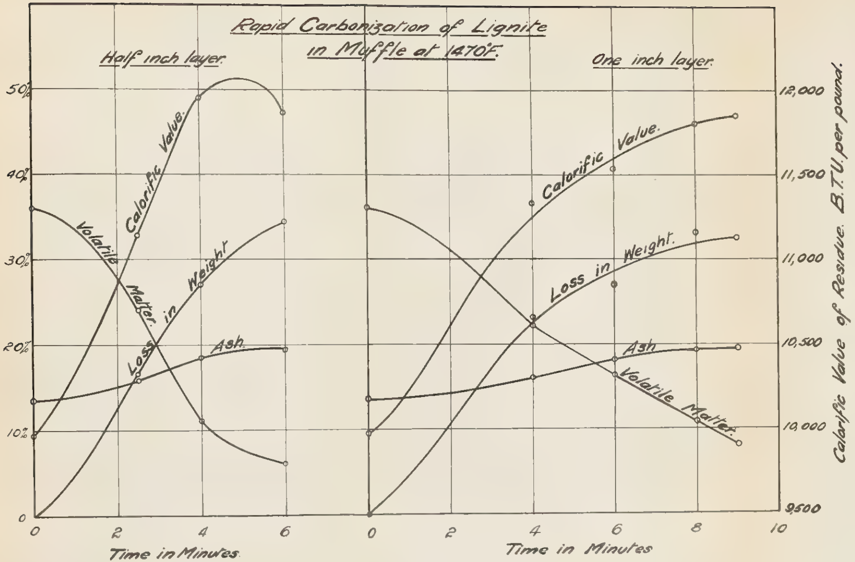


FIGURE 29

Rapid Carbonization of Lignite in Muffle

For text reference see page 164

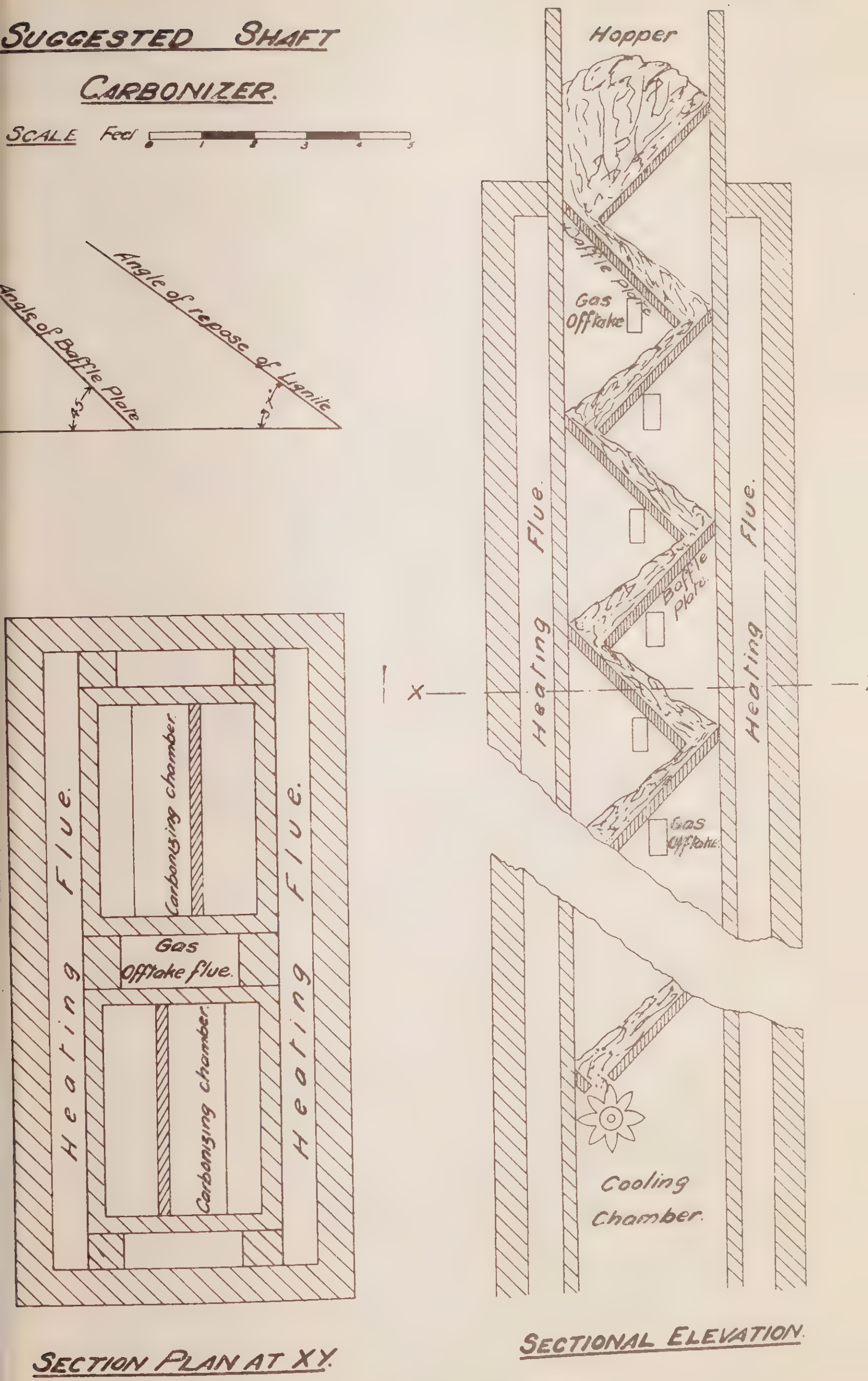


FIGURE 30

Suggested Shaft Carbonizer

For text reference see page 164

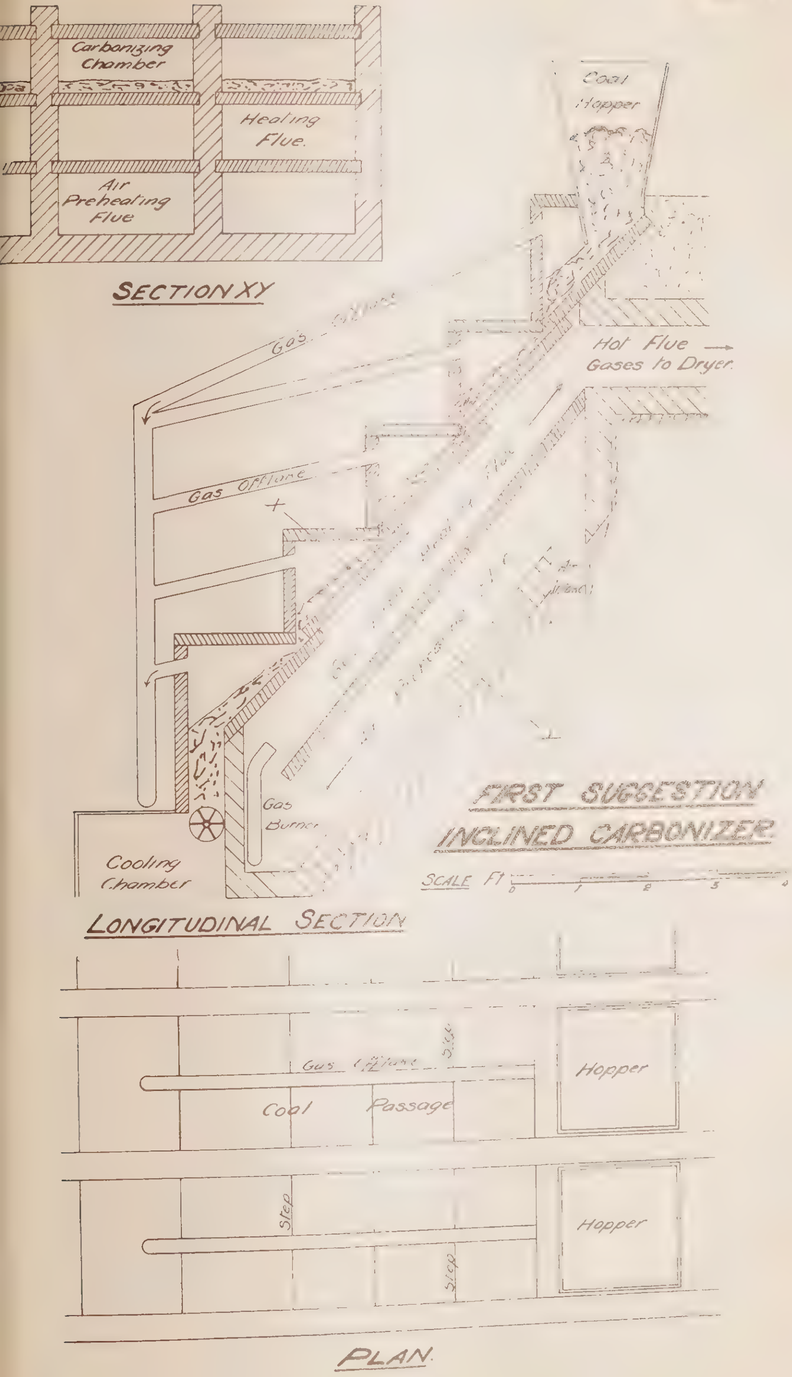


FIGURE 31

First Suggestion inclined Carbonizer

For text reference see page 165

Fig. 32

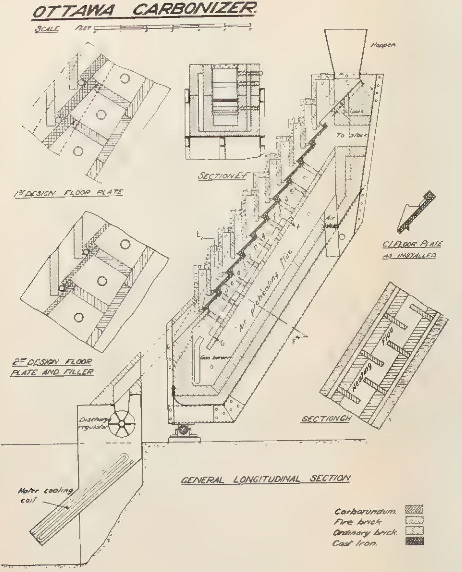


FIGURE 32
General Longitudinal Section Ottawa Carbonizer
For text reference see page 166

Fig. 33

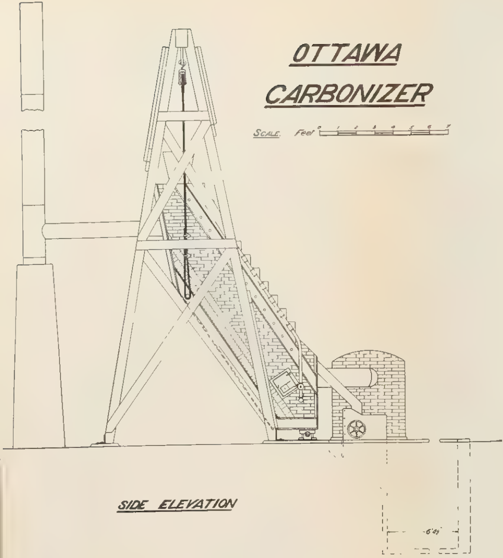


FIGURE 33
Scale Elevation of Ottawa Carbonizer
For text reference see page 166

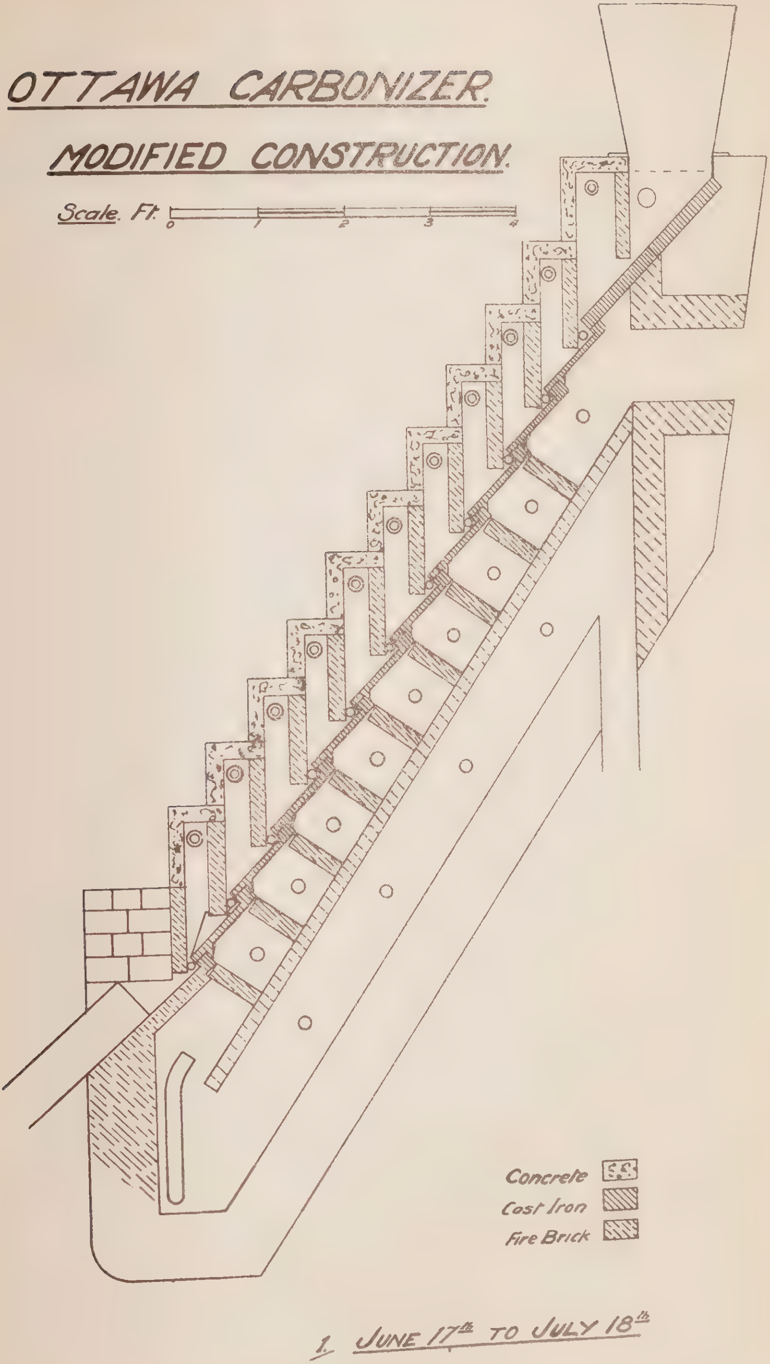


FIGURE 34
Modified Construction of Ottawa Carbonizer
(June 17th, to July 18th, 1919)

For text reference see page 167

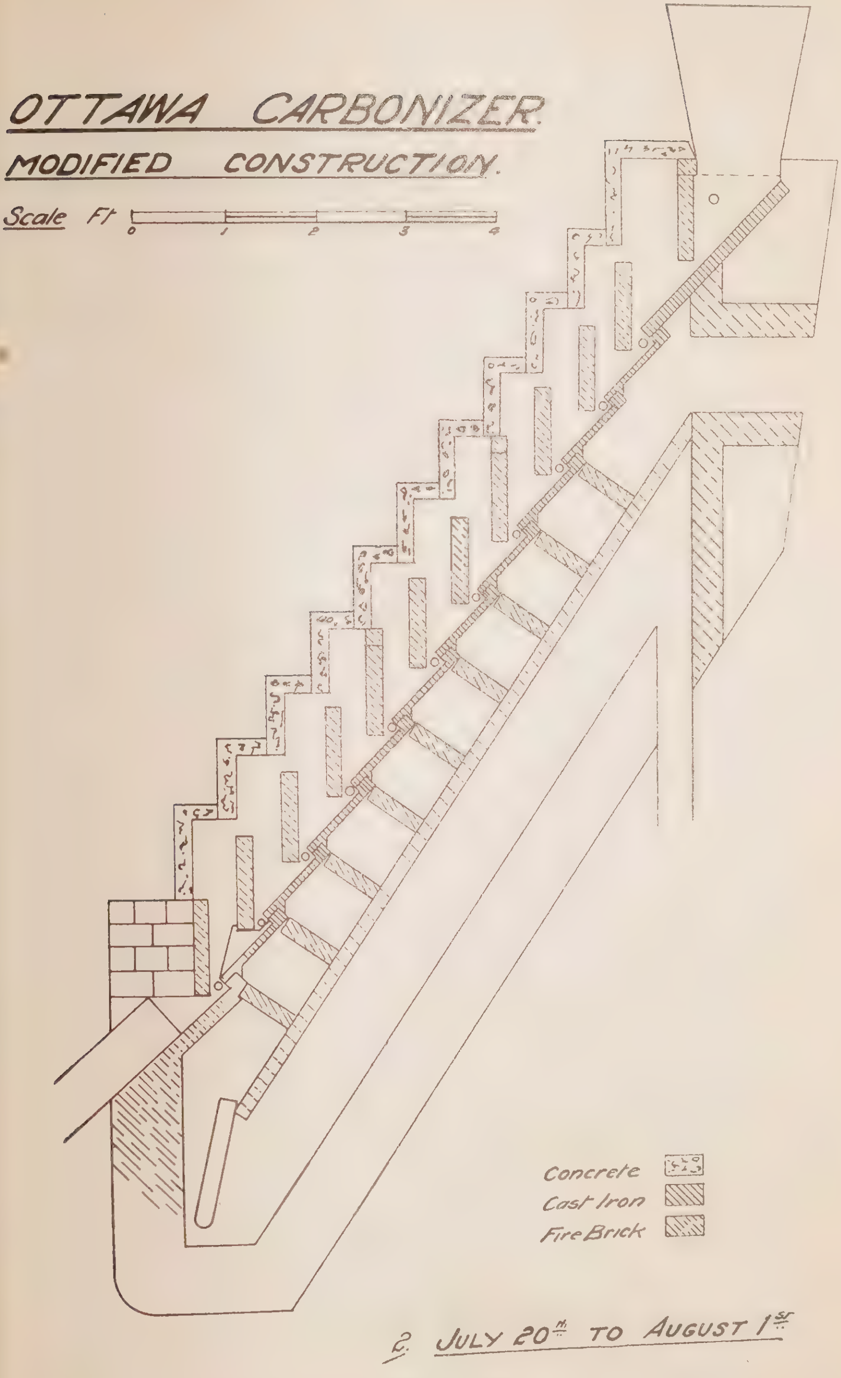


FIGURE 35

Modified Construction of Ottawa Carbonizer
(July 20th, to August 1st, 1919)

For text reference see page 168

Fig. 36

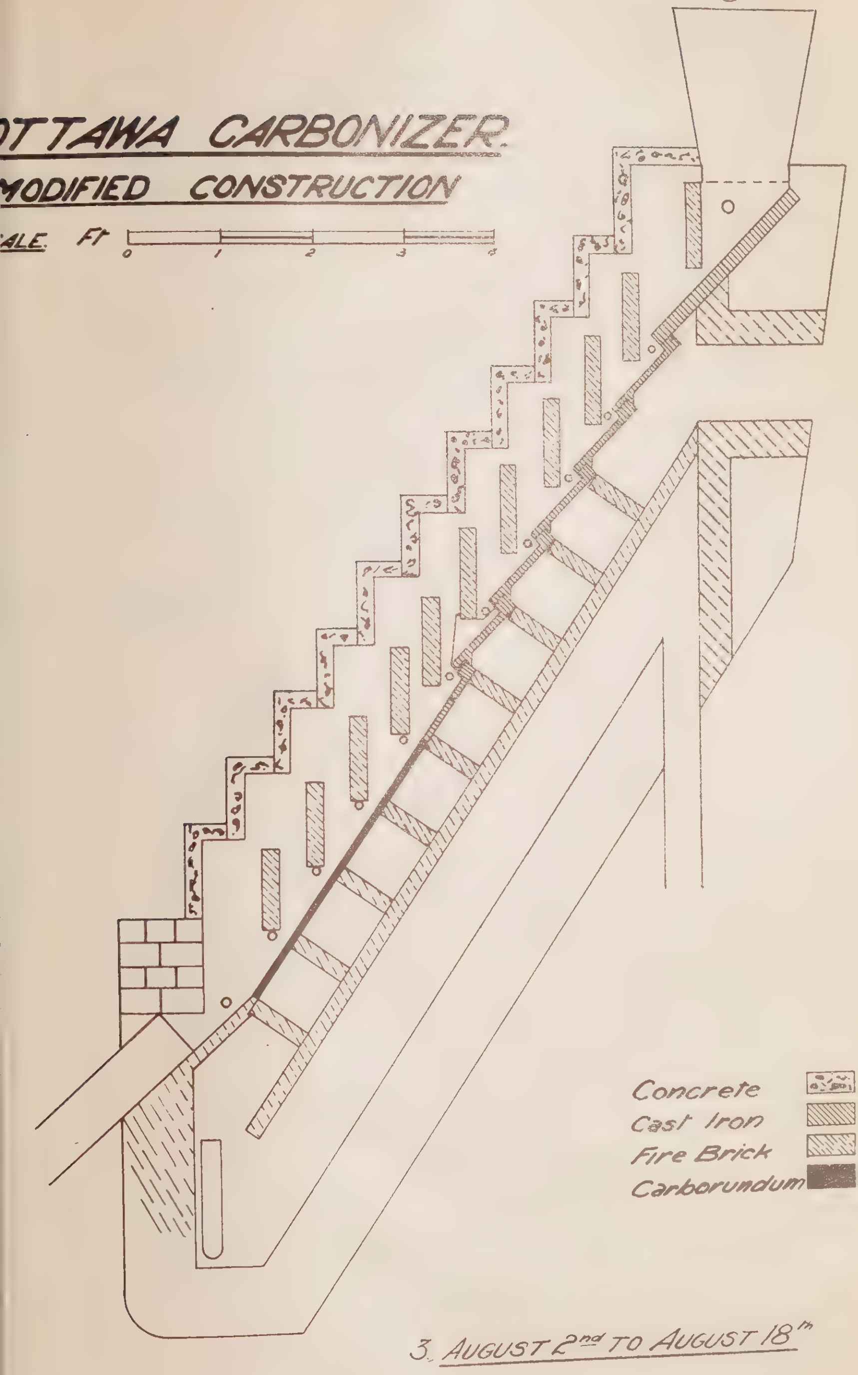


FIGURE 36
Modified Construction of Ottawa Carbonizer
(August 2nd, to August 18th, 1919)

For text reference see page 168

Fig. 37

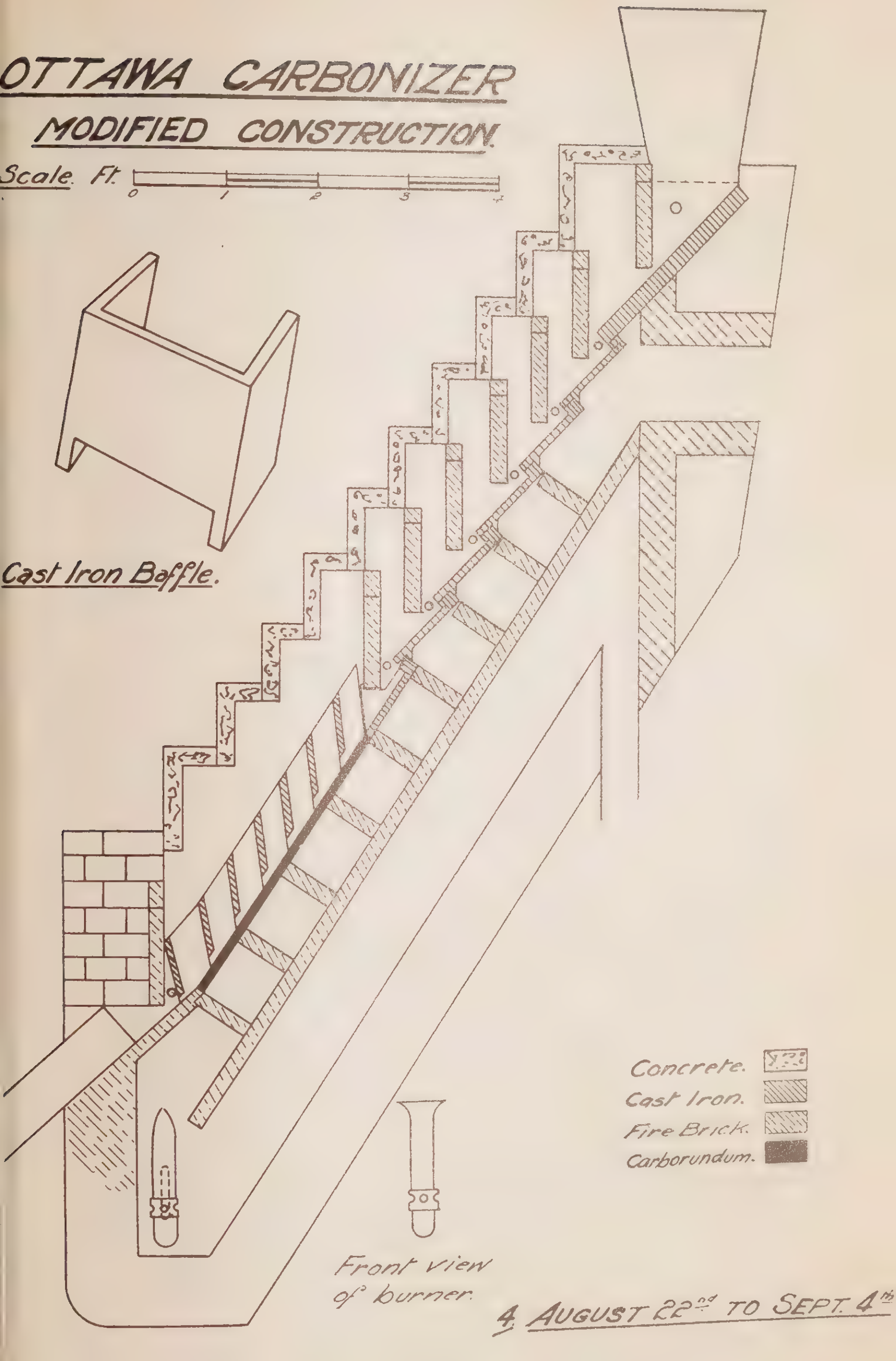


FIGURE 37
Modified Construction of Ottawa Carbonizer
(August 22nd, to Sept. 4th, 1919)

For text reference see page 169

Fig. 38

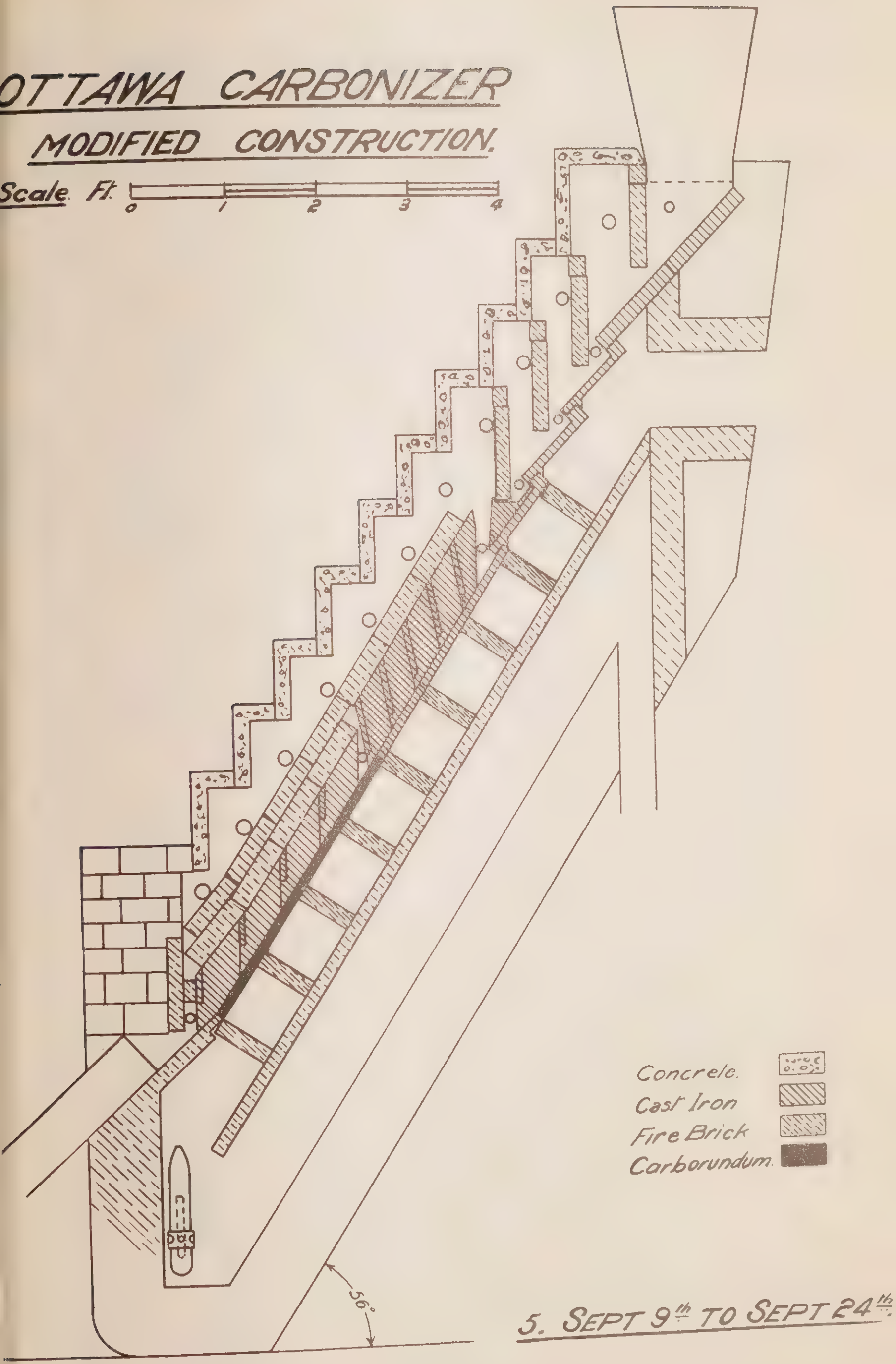


FIGURE 38

Modified Construction of Ottawa Carbonizer
(Sept. 9th, to Sept. 24th, 1919)

For text reference see page 170

Fig. 39

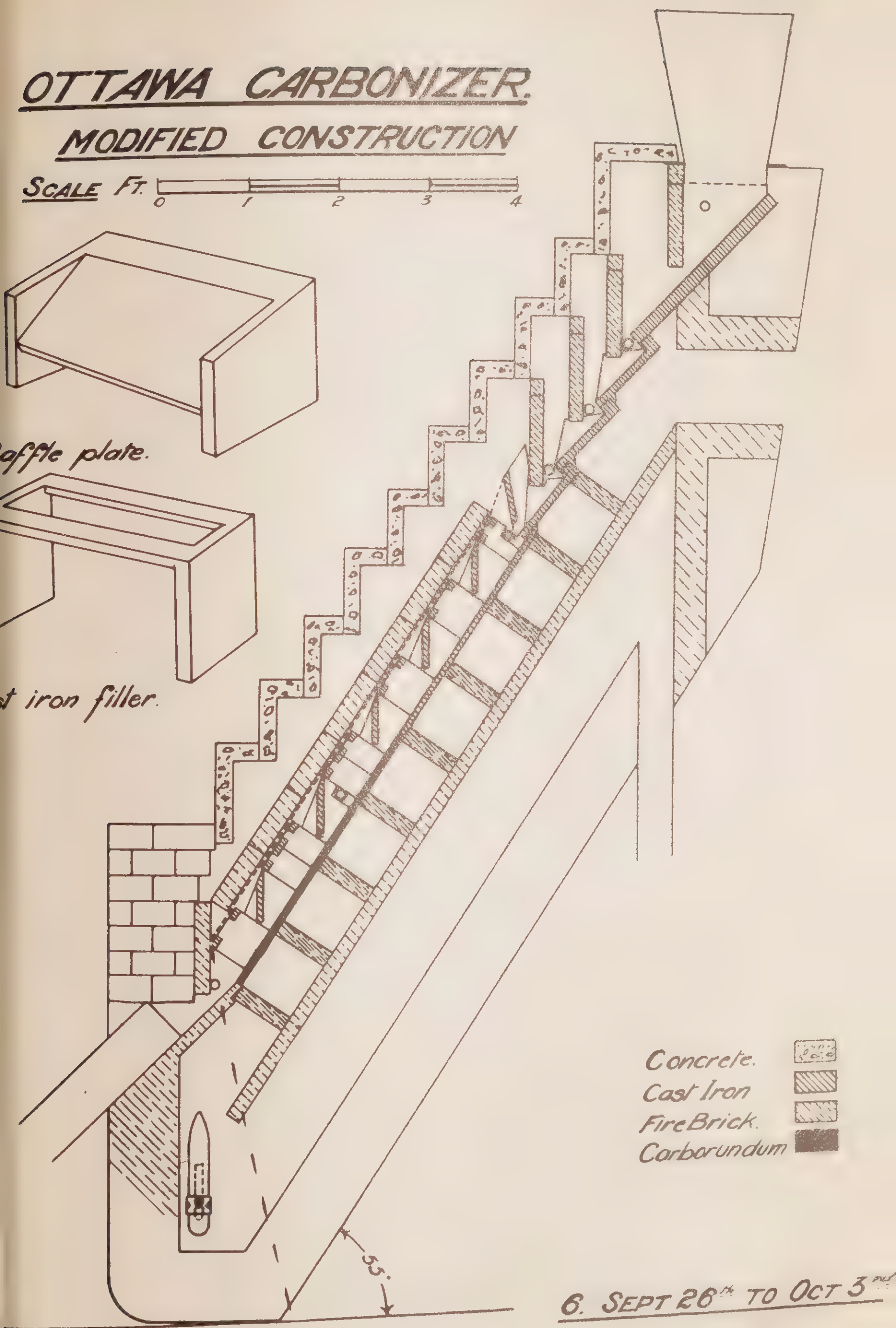


FIGURE 39
Modified Construction of Ottawa Carbonizer
(Sept. 26th, to Oct. 3rd 1919)

For text reference see page 171

Fig. 41

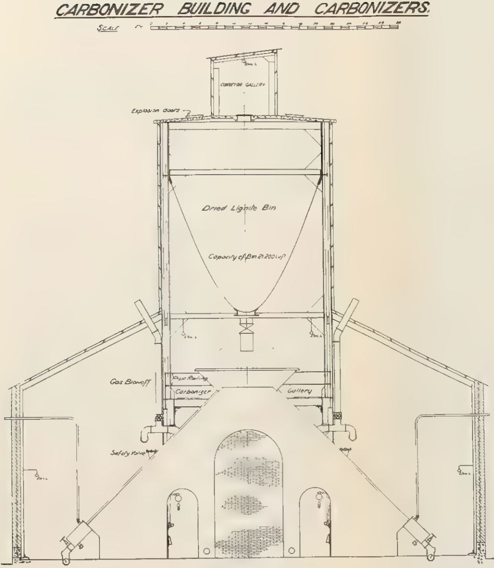


FIGURE 41

Carbonizer Building and Carbonizers — Sectional Elevation Bienfait Plant

For text reference see pages 175 and 184

Fig. 42

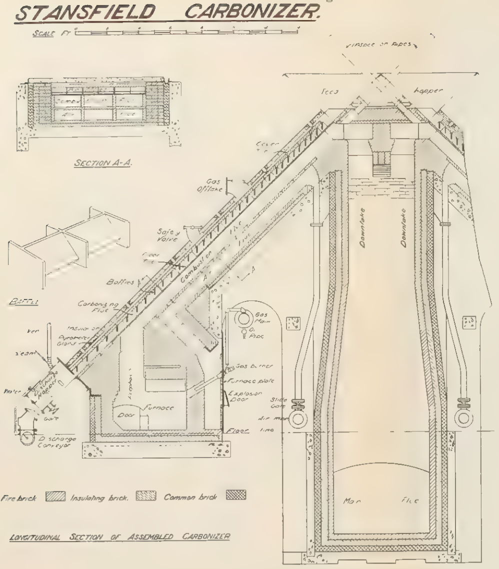


FIGURE 42

Longitudinal Section of Assembled Carbonizer Bienfait Plant

For text reference see page 176

Fig. 43

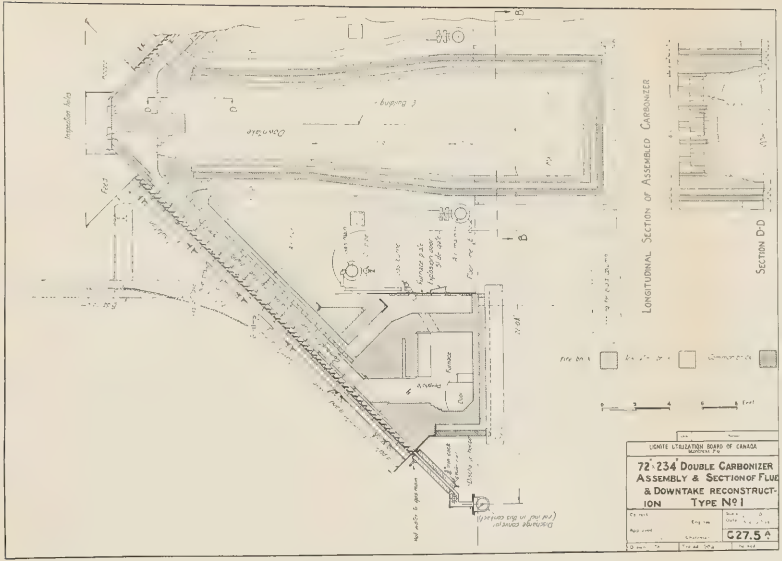


FIGURE 43
Stansfield Carbonizer after Reconstruction Aug. 15th, 1922

For text reference see page 190

Fig. 44

Fig. 44

Analysis of Canadian Materials Briquetted at Hebron, N.D.

Date – December, 1923	8	10	11	12	13	14	18	19	Average	20	21	Average
Prox. Anal. of Char.												
Moisture	1452		14.03	17.21	1406	14.82	16.73	17.82	15.60	14.75	16.00	15.37
Volatile	16.11		17.47	17.20	18.45	17.18	17.67	16.81	17.27	27.85	28.65	28.25
Fixed Carbon	56.58		55.55	5240	55.10	53.70	53.10	53.58	54.29	4535	44.65	45.00
Ash	1279		12.95	13.19	12.39	14.30	1250	11.79	1284	12.05	10.70	11.38
B.T.U.	9203		9305	8841	9260	8914	8808	8857	9027	8739	8767	8753
Dry Basis												
Volatile	1884		2032	20.78	21.47	2017	21.20	2045	2046	3267	3412	3340
Fixed Carbon	6620		6461	63.29	64.11	6304	63.80	6520	64.32	53.20	53.15	53.17
Ash	1496		1507	15.93	1442	16.79	15.00	14.35	15.22	1413	1273	1343
B.T.U.	10770		10815	10680	10770	10460	10578	10775	10692	10250	10430	10340
Prox. Anal. of Char Mix												
Moisture	1452	14.29	1488	16.12	13.94	14.12	1508	1615	1489	13.90	1685	15.37
Volatile	1611	16.93	1487	16.68	1815	17.16	1725	1825	1693	2750	2880	28.15
Fixed Carbon	5658	56.25	58.05	5485	5563	56.22	5515	54.25	5588	4700	44.30	45.65
Ash	1279	12.53	1220	1225	1228	1250	1252	1135	1230	1160	1005	1083
B.T.U.	9203	9431	9329	9081	9281	9370	9162	9374	9279	9126	8755	8940
Dry Basis												
Volatile	1884	19.75	1748	1990	21.09	19.98	2030	2177	1989	3194	3465	3330
Fixed Carbon	6620	65.62	6819	6550	64.69	65.47	65.00	6470	65.67	5460	53.27	53.93
Ash	1496	14.63	14.33	1460	14.22	14.55	14.70	1353	1444	1346	12.08	12.77
B.T.U.	10770	11003	10960	10825	10785	10910	10790	11170	10902	10600	10530	10565
Prox. Anal. of Briquets												
Moisture	11.28	10.89	10.16	1426	965	1288	1275	941	1141	870	8.50	860
Volatile	21.90	21.87	21.95	2282	2866	2278	2286	2337	22.66	3340	3430	33.85
Fixed Carbon	5550	5597	5688	5213	5578	5377	5367	5630	5500	4820	4745	4782
Ash	11.32	11.27	11.01	1079	10.91	10.57	1062	1092	1093	970	9.75	9.73
B.T.U.	10189	10104	10348	9847	10446	10075	9985	10250	10156	10226	10389	10307
Dry Basis												
Volatile	24.68	24.53	2443	2662	2619	2615	2630	2580	2559	3658	37.48	37.03
Fixed Carbon	62.56	6282	63.32	60.80	6174	6172	6153	6220	6209	5280	5187	5233
Ash	12.76	1265	1225	1258	1207	1213	12.17	1200	12.32	1062	1065	1064
B.T.U.	11475	11340	11520	11480	11570	11556	11444	11313	11462	11200	11350	11275

FIGURE 44
Chemical analyses Hebron briquetting test, Dec. 1923

For text reference see page 234

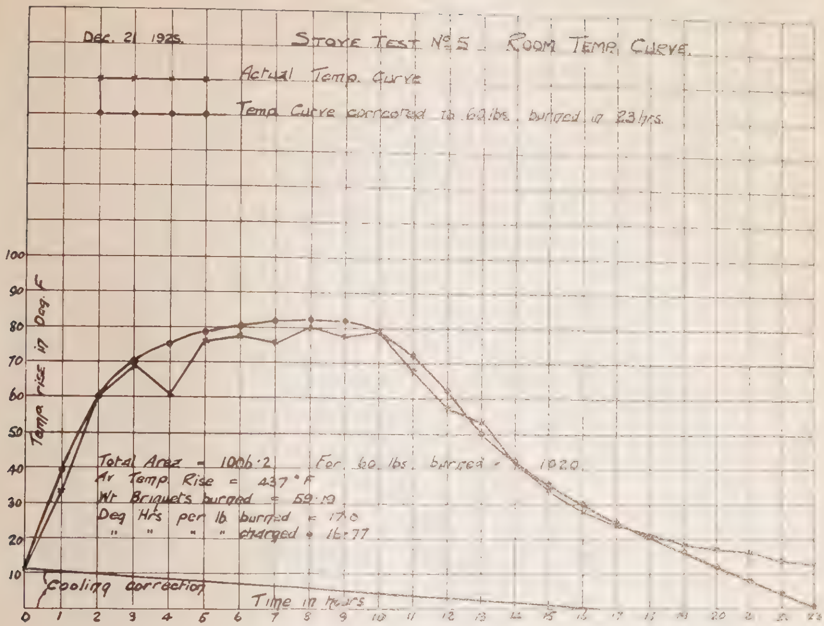


FIGURE 45-b

Stove test curve briquetting experiments, Dec. 1923, Hebron, N D.

For text reference see page [illegible]

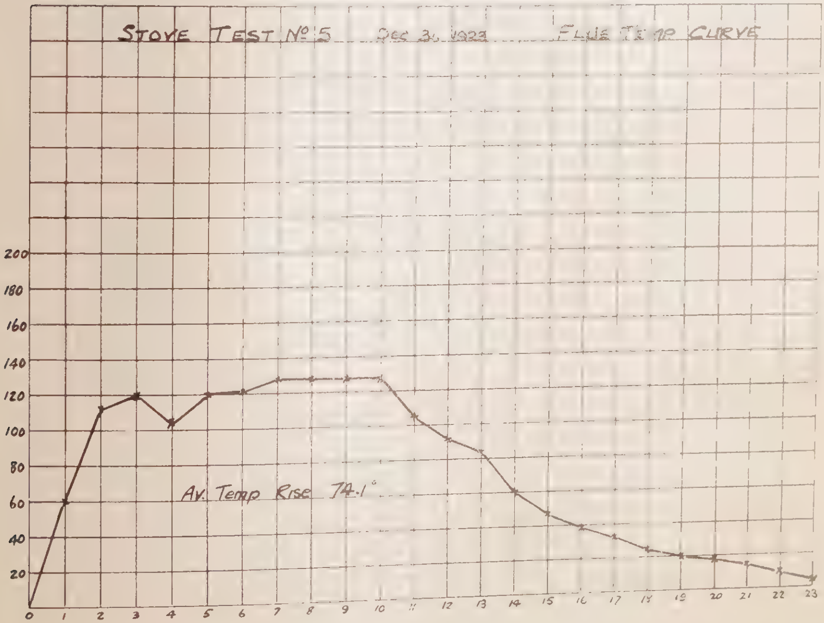


FIGURE 45-a

Stove test curve briquetting experiments, Dec. 1923, Hebron, N. D.

For text reference see page 236

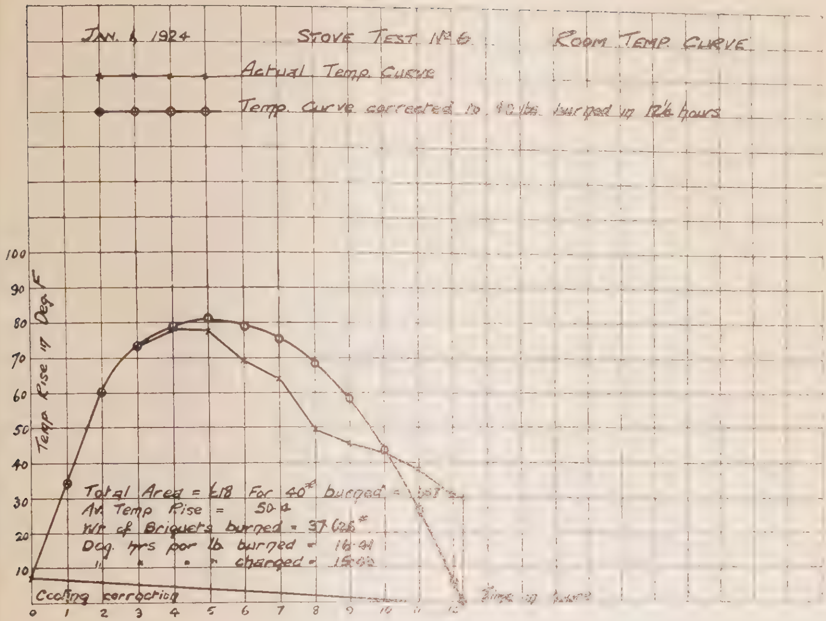


FIGURE 45-d

Stove test curve briquetting experiments, Dec. 1923, Hebron, N. D.

For text reference see page 236

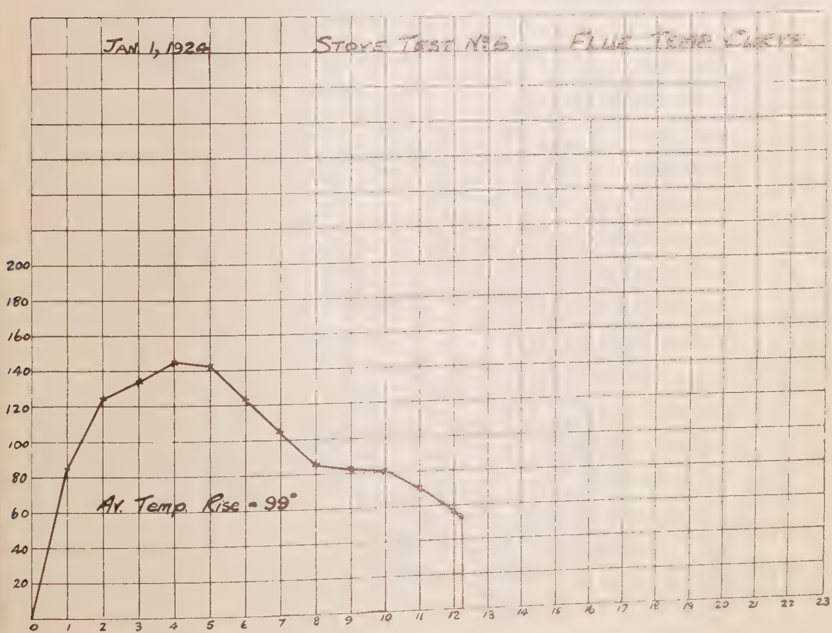


FIGURE 45-c

Stove test curve briquetting experiments, Dec. 1923, Hebron N.D.

For text reference see page 236

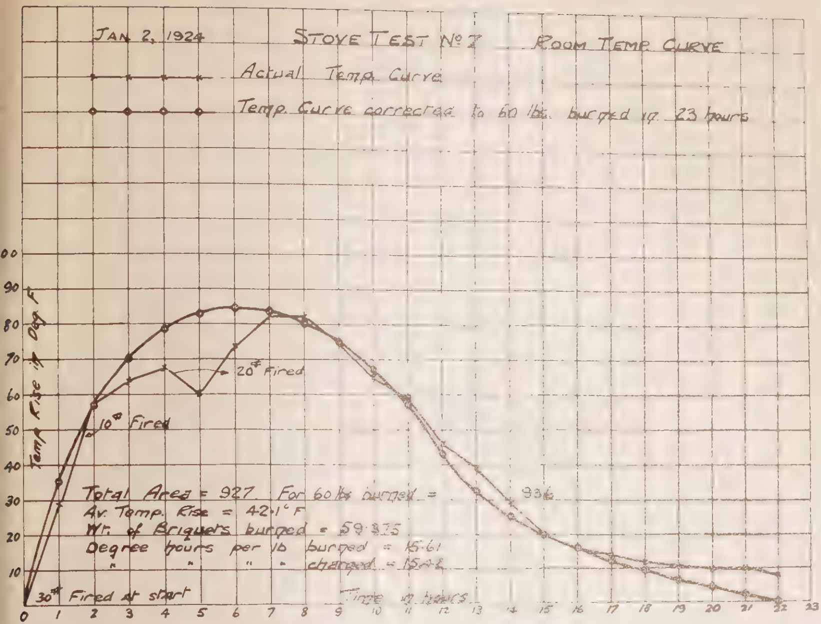


FIGURE 45-f

Stove test curve briquetting experiments, Dec. 1923, Hebron, N. D.

For text reference see page 236

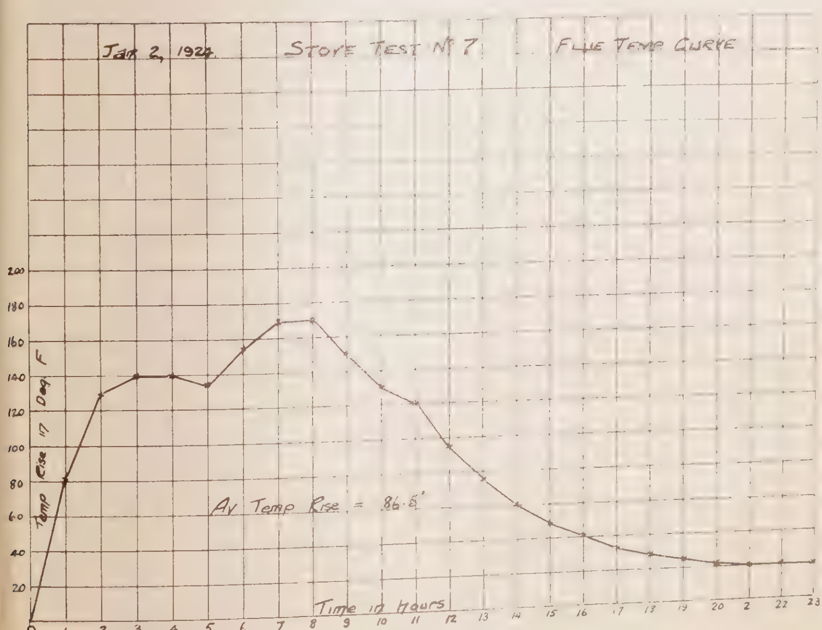


FIGURE 45-e

Stove test curve briquetting experiments, Dec. 1923, Hebron, N. D.

For text reference see page 236

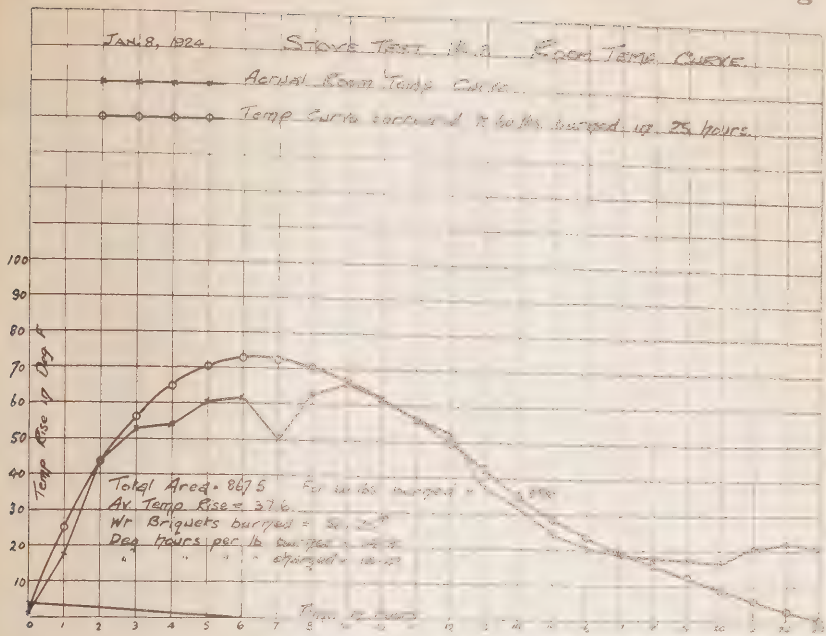


FIGURE 45-h

Stove test curve briquetting experiments, Dec. 1923, Hebron, N.D.

For text reference see page 236

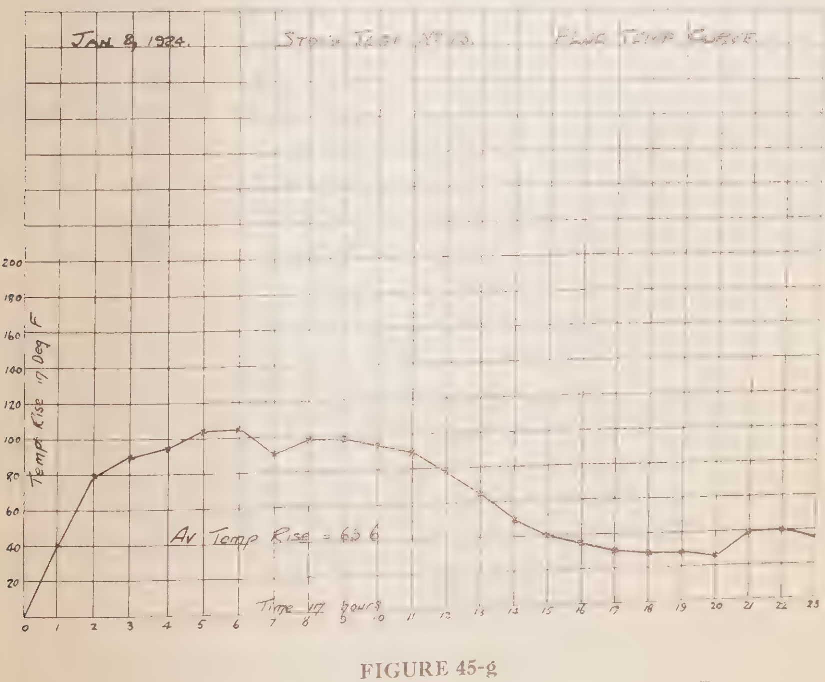


FIGURE 45-g

Stove test curve briquetting experiments, Dec. 1923, Hebron, N. D.

For text reference see page 236

RESULT OF STOVE TESTS

Date	Dec 31 1923			
Description of Fuel burned in test.	Briquets made at Hebron Dec 8 to 14	Briquets made at Hebron Dec. 18 and 19		
Stove Test No	5	6	13	7
Prox Anal of Fuel				
Moisture	6 93	8.45	13.35	9 42
Volatile	22 90	21.57	21 42	30 52
Fixed Carbon	59 05	59.25	54 59	51 13
Ash	11 07	10 73	10 64	8 93
Outdoor Temp at start	-15°	-11°		-5°
Temp in Test Room at start	84	79	90	75
" outside " " " "	73	72	86	75
Wind Direction	N W.	S W.	North	N W.
" Velocity (High, Medium, Low)	Low	Medium	Low	Low
Pipe Draft Velocity (Ft per min)	205	205	208	208
Wt Fuel charged (lbs)	60	40	60	60
Duration of Test (hrs)	23	12¼	23	22
Front draft open at start (min)	30	30	30	30
Wt Fuel unburned (lbs)	81	2375	1875	625
" " burned (lbs.)	59.19	37.625	58.125	59.375
Wt of Ash (lbs.)	6.53	3.94	5.56	5.47
% of Ash	11 02	10 45	9.58	9.22
% of Combustible in Ash	3.52	13 27	.55	.50
Highest Room Temp.	163	165	168	169
" Flue "	230	235	218	248
Total Avail. Heat in Degree hours	1006	618	868	927
Avail. Heat per lb burned Deg. hrs	17.00	16.41	14.91	15.61
B.T.U of Fuel	10674	10649	10071	10112

Stove Test No. 5 was made on briquets made Dec. 8-10-11-12-13-14 and represents the main body of the briquetting tests.

Stove Tests 6 and 13 were made on the product of Dec. 18 and 19 which differs from the earlier briquets in having in the binder, 20% of Lignite pitch.

Stove Test No. 7 covers the high volatile material of the last car treated. The binder was coal tar pitch and flour.

FIGURE 46

Table showing results of stove tests briquetting experiments, Hebron, N. D.

For text reference see page 236

Fig. 47

Fig. 47

CHART No 1

Lot No		1	1	2	2	1	1	3	3	3
Date of Manufacture 1923		Nov 30	Dec 1	Dec 3	Dec 4	Dec 5	Dec 5	Dec 24	Dec 24	Dec 26
Composition of Briquette		Medium Volatile		High Volatile		Medium Volatile		Low Volatile		
	Char + Moisture %	80.62		79.33		80.50	8050	8304	90.04	8525
	Coking Coal	727		7.25		7.25	7.25	7.00	000	000
	Flour	176		175		175	175	175	175	1.75
	Coal Tar Pitch	10.45		11.67		App 840	App 9.70	821	821	000
	Lignite Pitch	000		000		210	80	0.00	000	App 1300
Prox. Anal. of Char										
As Rec'd	Moisture	1160		1303	1631	1160			1285	
	Volatile	1819		2758	2105	1619			1010	
	Fixed Carbon	5908		5047	46.20	5908			6442	
	Ash	1113		692	1038	1113			1260	
	B.T.U.	10429		9237	9175	10429			10173	
Dry Basis	Volatile	2058		3170	3235	2088			1160	
	Fixed Carbon	6683		5605	5523	6652			7394	
	Ash	1259		1025	12.42	1260			1446	
	B.T.U.	11799		10686	10971	11799			11670	
Prox Anal of Char Mix										
As Rec'd	Moisture	666	11.59	1540	1529	1214	1263	355		300
	Volatile	1965	19.06	2719	2870	2098	2015	1470		1542
	Fixed Carbon	5993	5742	4698	4622	5505	5519	6822		6661
	Ash	1186	1193	1043	979	1183	1203	1403		1497
	B T U	10446	10185	9708	9333	10262	9896	11069		11045
Dry Basis	Volatile	21.40	21.56	3210	3590	2365	2306	1516		10.90
	Fixed Carbon	6562	6494	5558	5454	6269	6317	7037		6867
	Ash	1298	13.50	1232	1156	1346	1377	1447		1543
	B T U	11436	11621	11475	11019	11680	11323	11430		11380
Prox Anal of Briquets										
As Rec'd	Moisture	912	9.19	1529	1818	14.62	1261	212	221	405
	Volatile	2426	2342	2956	3132	2600	2196	1692	1670	20.70
	Fixed Carbon	55.29	55.46	46.47	4200	4909	5481	6632	6552	6236
	Ash	1133	11.34	868	650	1029	1062	1324	1357	12.89
	B T U	10564	10560	9810	9362	9981	10193	11627	11586	11538
Dry Basis	Volatile	2670	2595	3490	3830	3042	2510	1870	1910	2155
	Fixed Carbon	6090	6149	5485	5130	5753	6275	6780	6703	6500
	Ash	1240	1256	1025	1040	1206	1215	1350	1387	1345
	B T U	11622	11707	11276	11442	11687	11662	11876	11846	12019

FIGURE 47

Table of chemical analyses briquetting experiments, Grand Forks, N. D.

For text reference see page 289

Fig. 48

Fig. 48

CHART No. 2

Stove Test Data. Canadian Briquetting Tests at the School of Mines, University of North Dakota

Date: Jan. 3, 1924

Description of Fuel burned in Test	Canadian Briquets made at Grand Forks — 7% Coking Coal —					
	10-15 % Vol Char Std. Binder	20-30 % Vol Char Std Binder	10-15 % Vol Char 25% Liq. Pitch 75% C.T. "	Low Vol Char All Lignite Pitch 1/2 Coking Coal	Low Vol Char with Coking Coal Std Binder	Low Vol Char without Coking Coal Std. Binder
Stove Test No.	8	9	10	11	12	15
Prox. Anal — Moisture	7.45	10.27	5.61	4.05	8.20	3 75
Prox. Anal — Volatile	24.15	30.59	18.07	20.70	18 49	16 77
Prox. Anal — Fixed Carbon	57.18	49.80	60.15	62.36	61 06	66.45
Prox. Anal — Ash	11.22	9.34	16.17	12.89	12 25	13 03
Outdoor Temp. at start						
Temp. in Test Room at start	78	79	76	86	88	79
Temp. outside Test Room at start	74	75	72	83	86	79
Wind — Direction	N.W.	North	South	North	N.E.	South
Wind — Velocity (High, medium, low)	Medium	Medium	Medium	Low	Low	Low
Pipe Draft Velocity (Ft. per min)	195	198	203	208	194	205
Wt. Fuel charged (lbs)	60	60	60	60	60	60
Duration of Test (hrs.)	23	23	23 1/2	23	23	23
Front draft open at start (min)	30	30	30	30	30	45
Wt. Fuel unburned (lbs.)	.44	.19	1.438	3.0625	2 06	2 56
" " burned (lbs.)	59.56	59.81	58.562	56.9375	57.94	57 44
Wt. of Ash (lbs)	6.844	5.625	6.594	6.0625	6 44	6 875
% of Ash	11.46	9.41	11.22	10.64	11.12	11 96
% of Combustible in Ash	9 47	16.4	6 3	1.45	95	2.22
Highest Room Temp.	157	156	157	172	180	171
" Flue "	215	215	218	210	252	240
Total Avail Heat in Degree hours	1067.5	1041	1052	953	1029	1013.5
Avail Heat per lb burned Deg hrs	17.92	18.25	17 97	16 72	17 72	17.64
B.T.U of Fuel	10960	10633	10935	11538	11118	11961

FIGURE 48

Table of results of stove tests briquetting experiments, Grand Forks N. D

For text reference see page 241

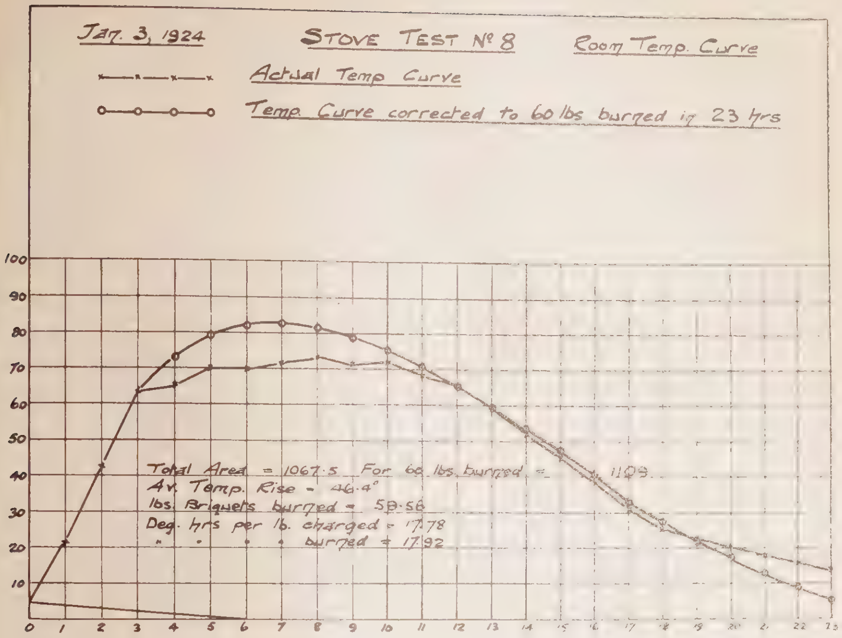


FIGURE 49-a

Stove test curve briquetting experiments, Grand Forks, N. D.

For text reference see page 242

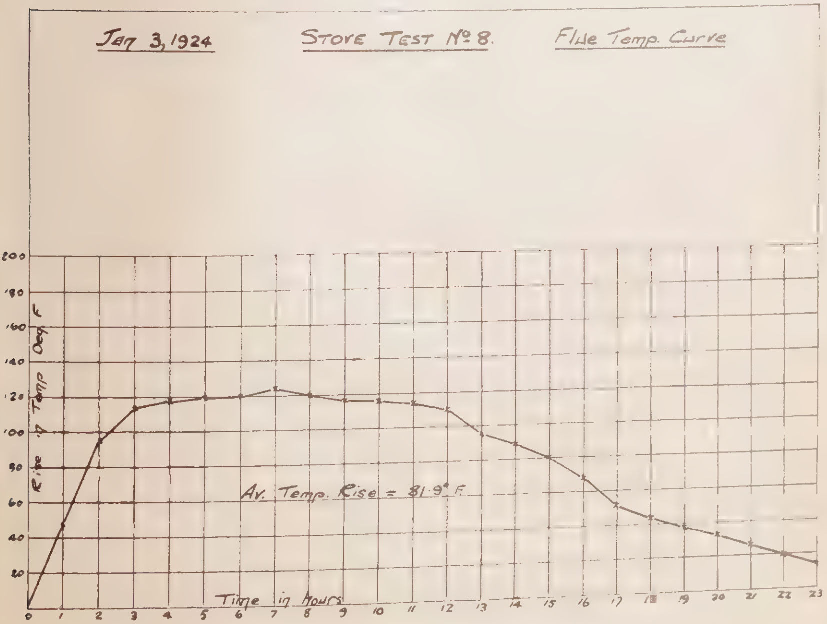


FIGURE 49-b

Stove test briquetting experiments, Grand Forks, N. D.

For text reference see page 242

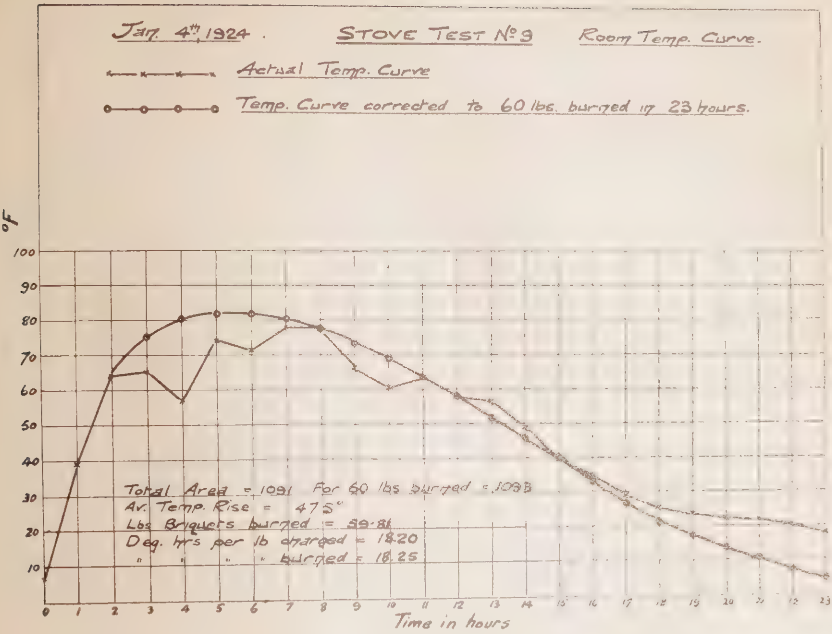


FIGURE 49-c

Stove test curve briquetting experiments, Grand Forks, N. D.

For text reference see page 242

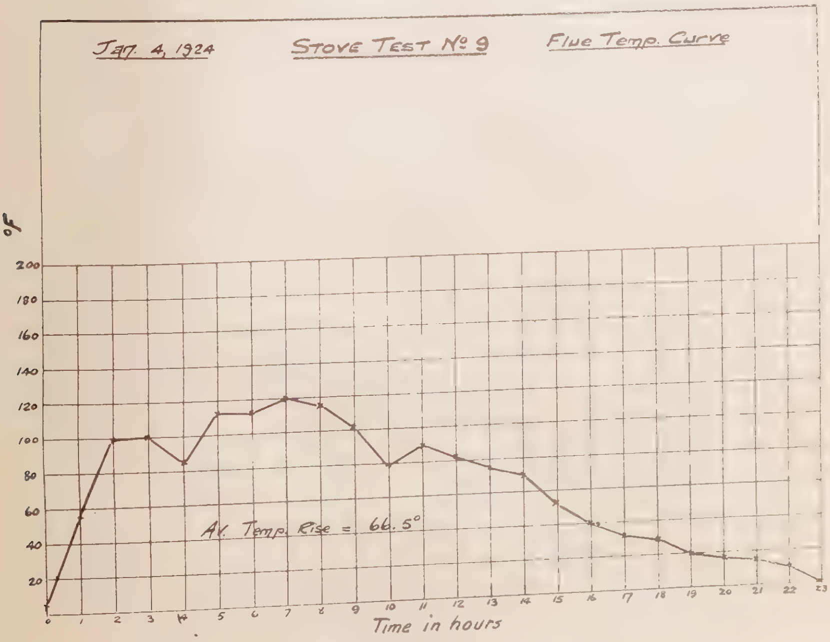


FIGURE 49-d

Stove test curve briquetting experiments, Grand Forks, N. D.

For text reference see page 242

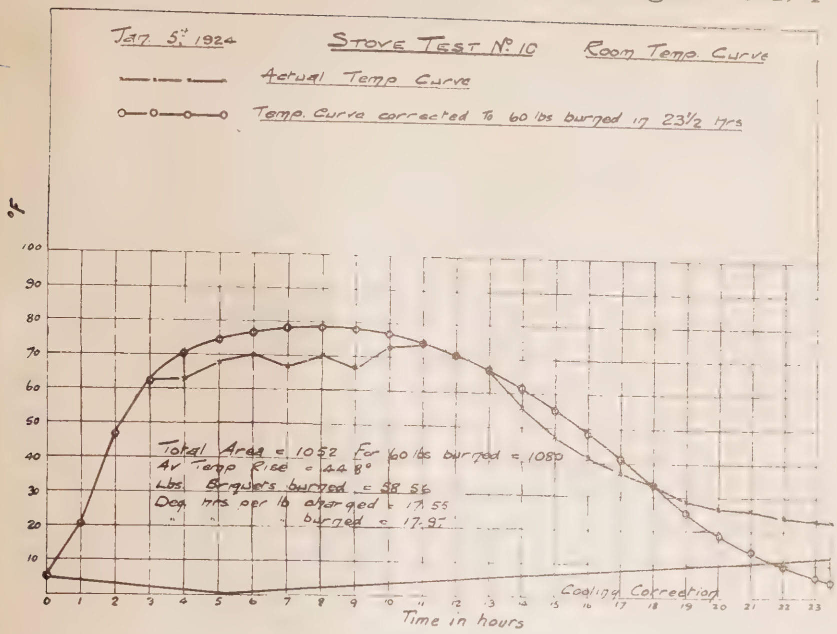


FIGURE 49-e

Stove test curve briquetting experiments, Grand Forks, N. D.

For text reference see page 242

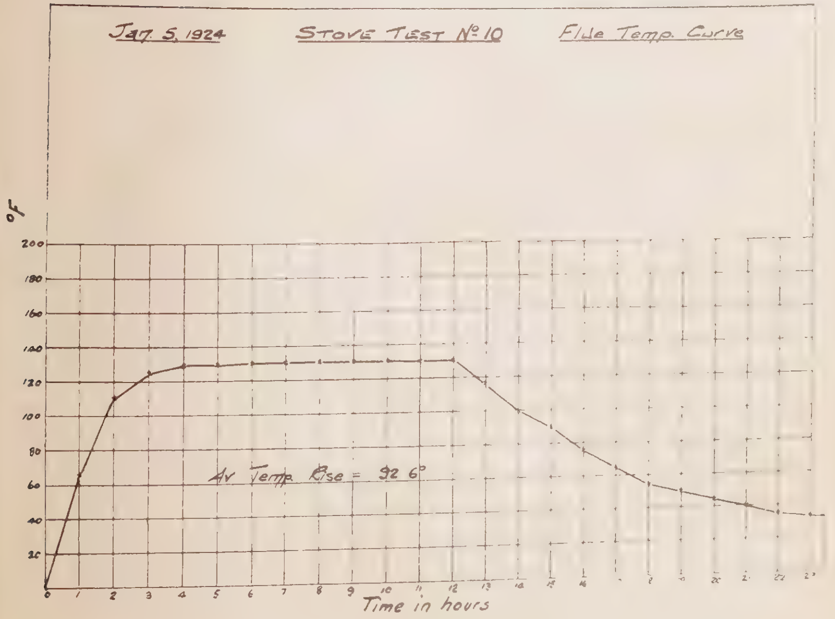


FIGURE 49-f

Stove test curve briquetting experiments, Grand Forks, N. D.

For text reference see page 242

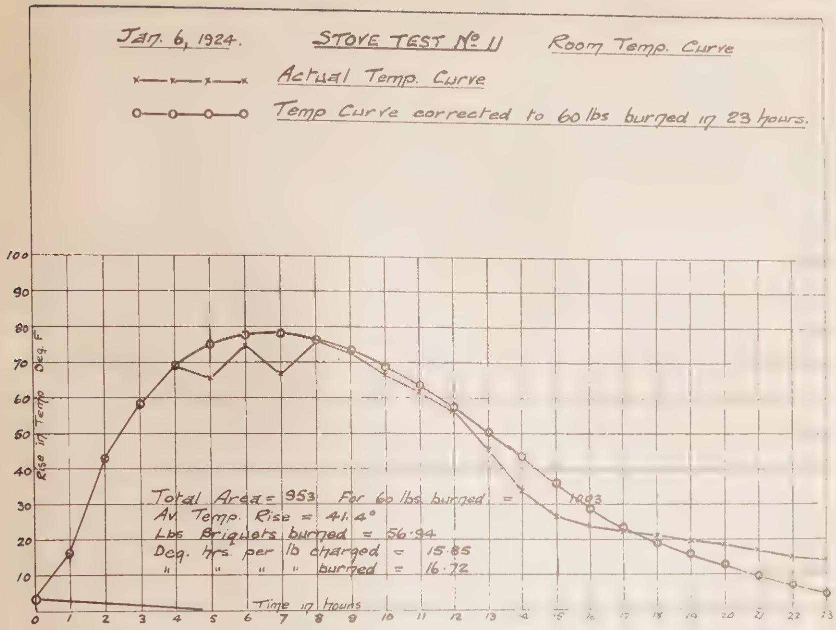


FIGURE 49-g

Stove test curve briquetting experiments, Grand Forks, N. D.

For text reference see page 242

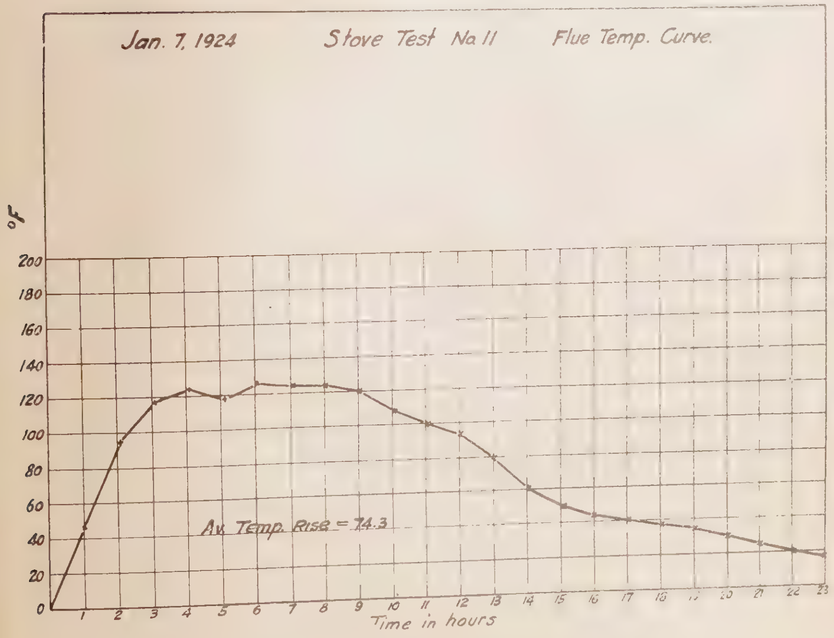


FIGURE 49-h

Stove test curve briquetting experiments, Grand Forks, N. D.

For text reference see page 242

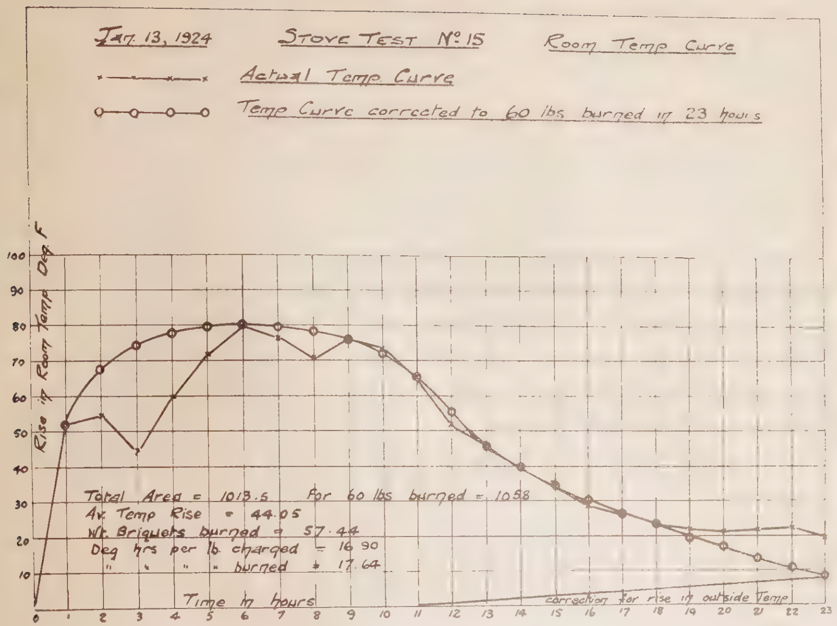


FIGURE 49-k

Stove test curve briquetting experiments, Grand Forks, N. D.

For text reference see page 242

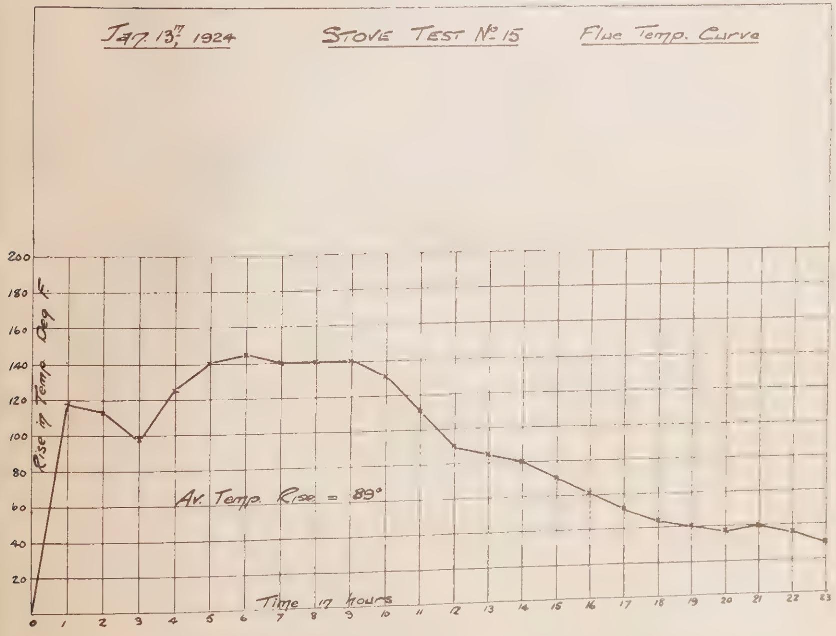


FIGURE 49-1

Stove test curve briquetting experiments, Jan. 1924, Grand Forks, N. D

For text reference see page 242

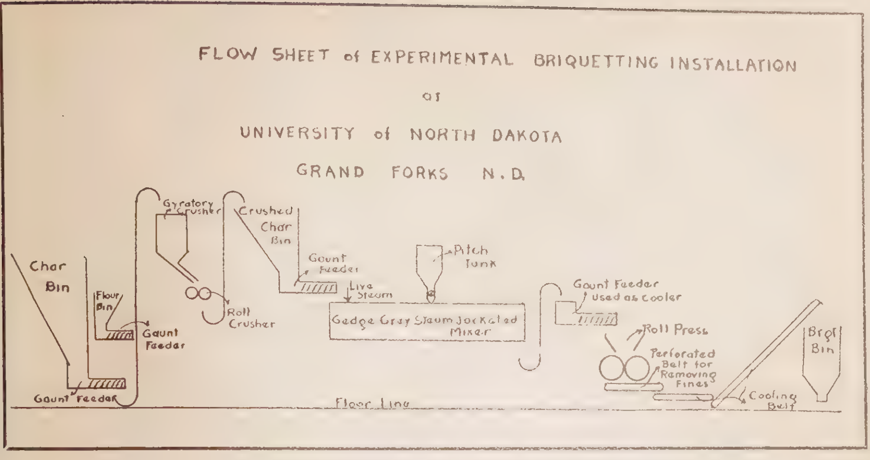


FIGURE 50

Flow sheet of briquetting installation, Grand Forks, N. D.

For text reference see page 239

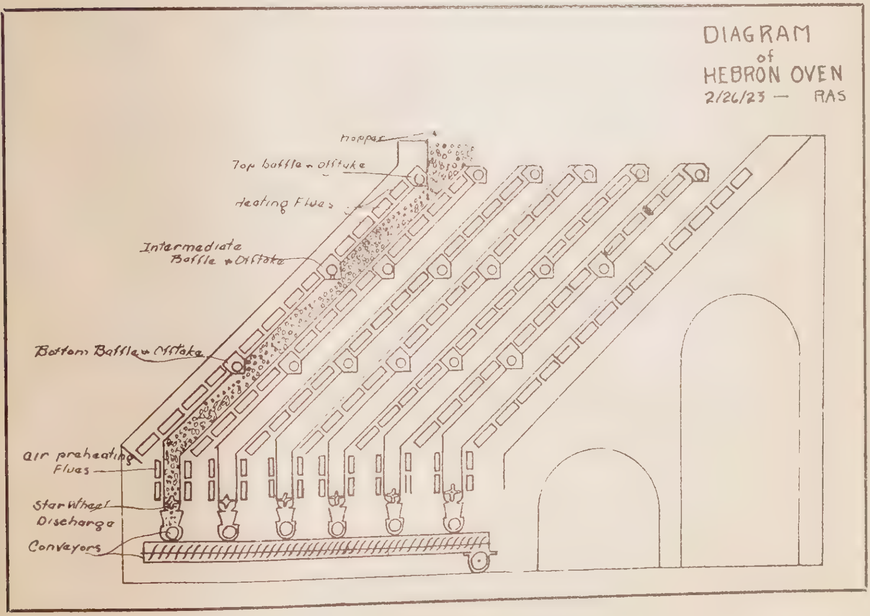


FIGURE 51

Diagrammatic elevation of Hebron retort

For text reference see page 229

Fig. 52

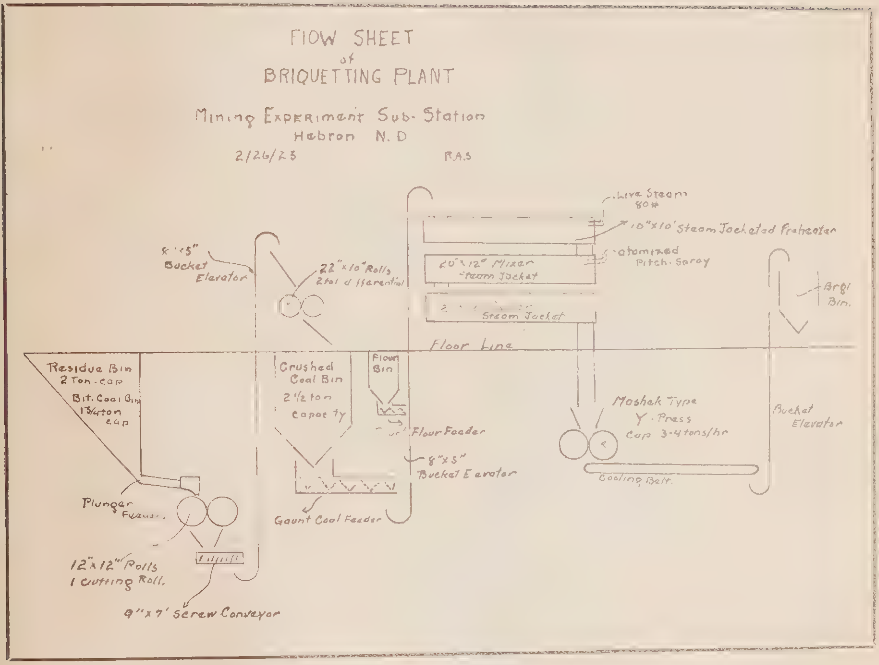


FIGURE 52

Flow sheet of briquetting installation, Hebron, N. D.

For text reference see page 229

Fig. 53

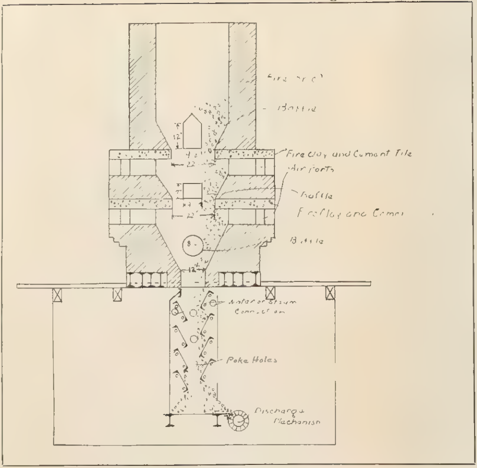


FIGURE 53

Hood-Odell shaft carbonizer as erected at Grand Forks, N.D.

For text reference see page 217

Fig. 54

Fig. 54

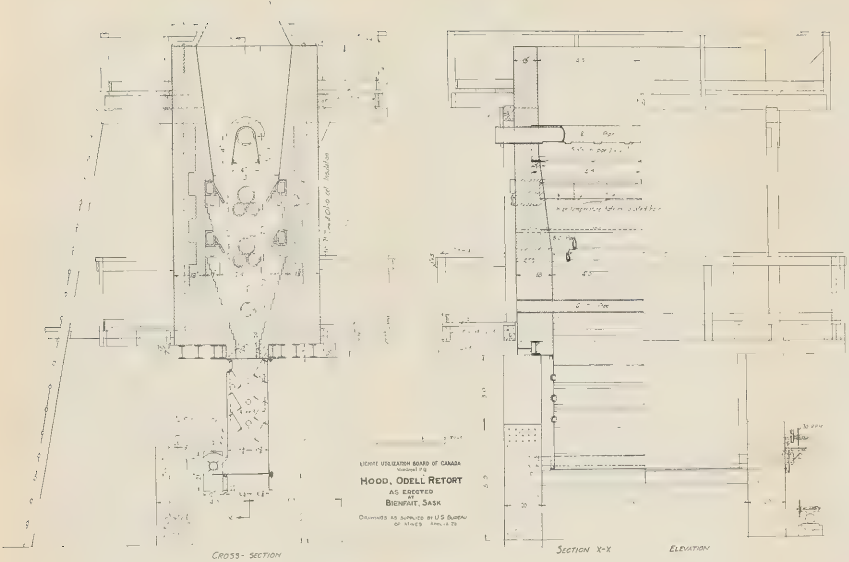
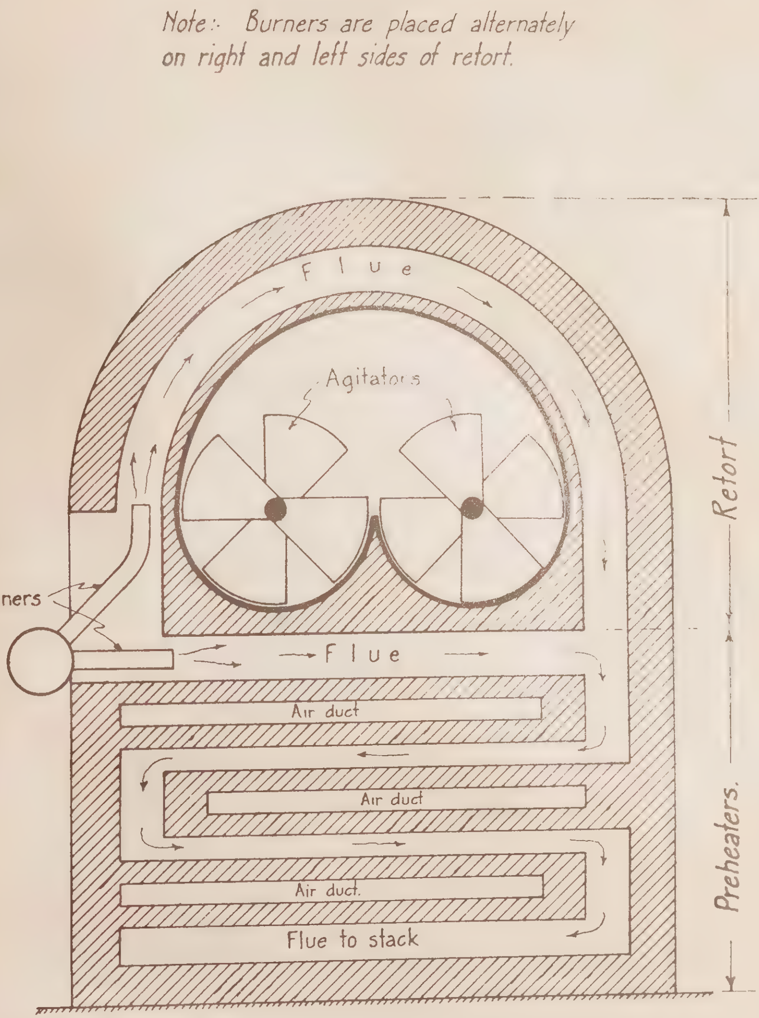


FIGURE 54
Hood-Odell shaft carbonizer as erected at Bienfait

For text reference see page 219



SECTION OF SMITH "CARBOCOAL" RETORT
International Coal Products Corpn., Irvington, N.J.

FIGURE 55

For text reference see page 143

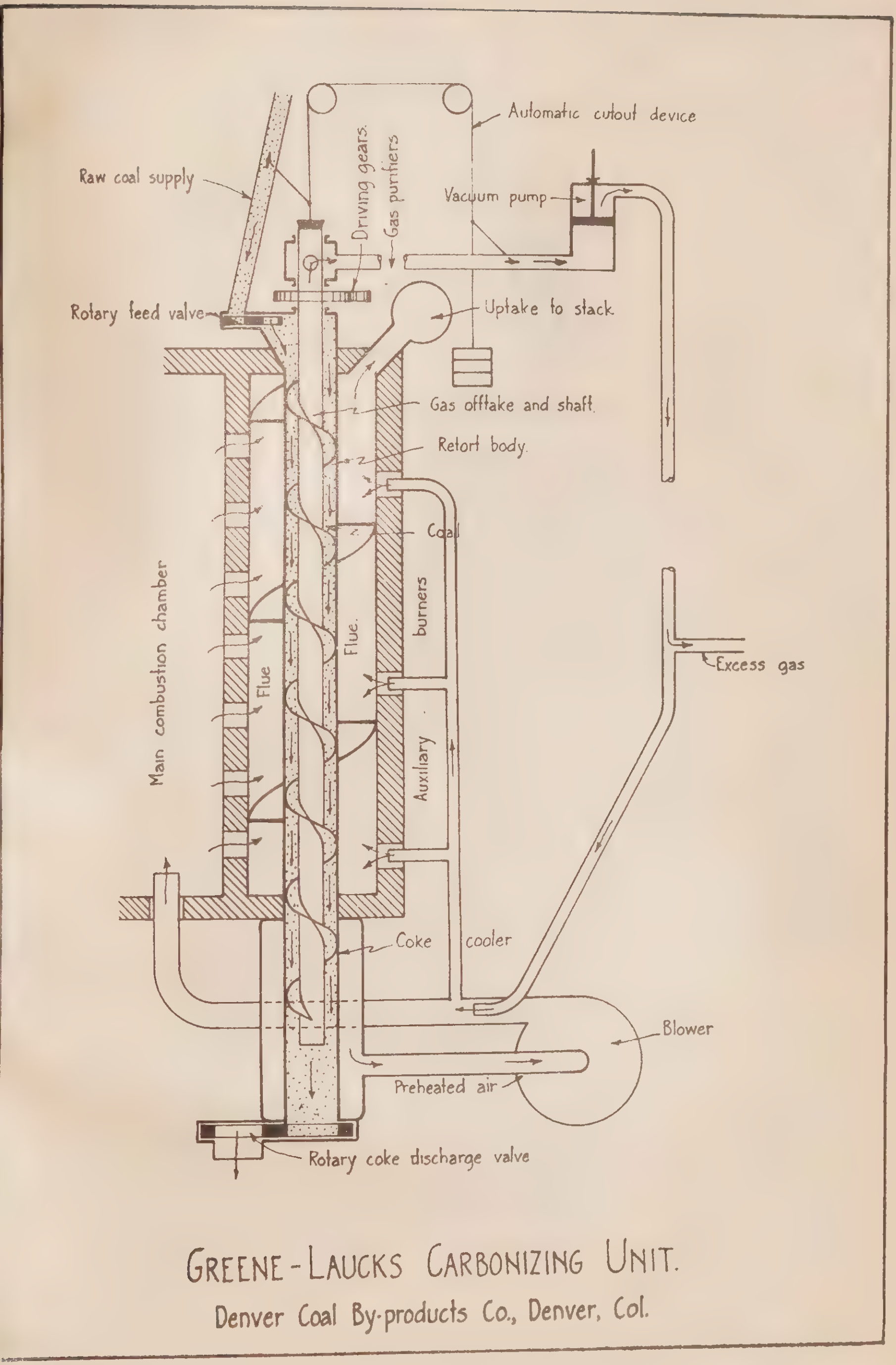
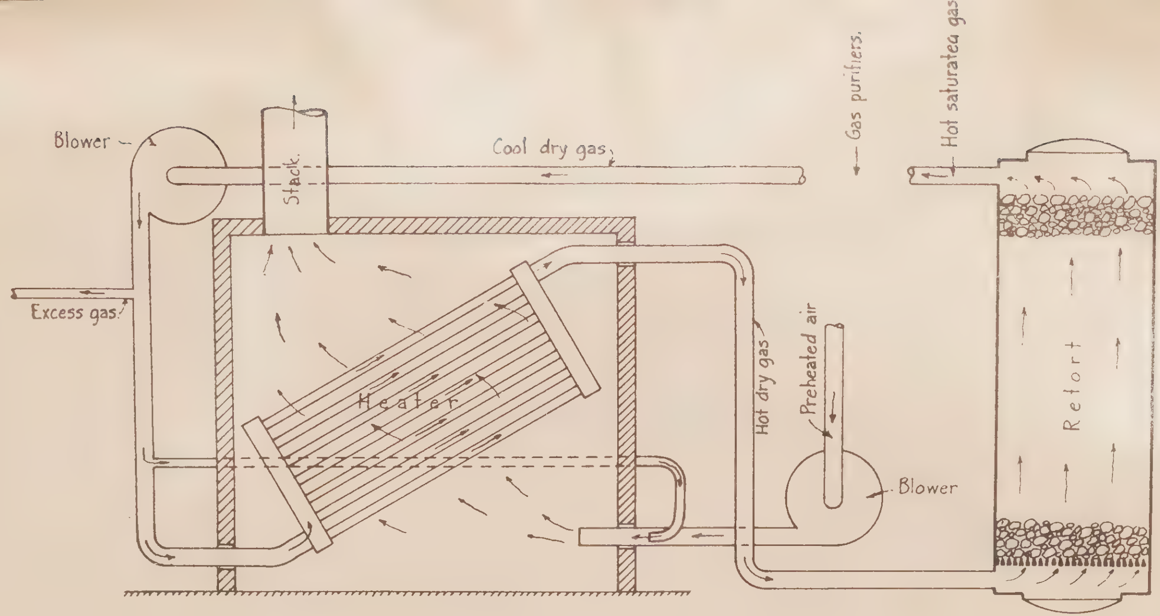


FIGURE 56

For text reference see page 143

Fig. 57



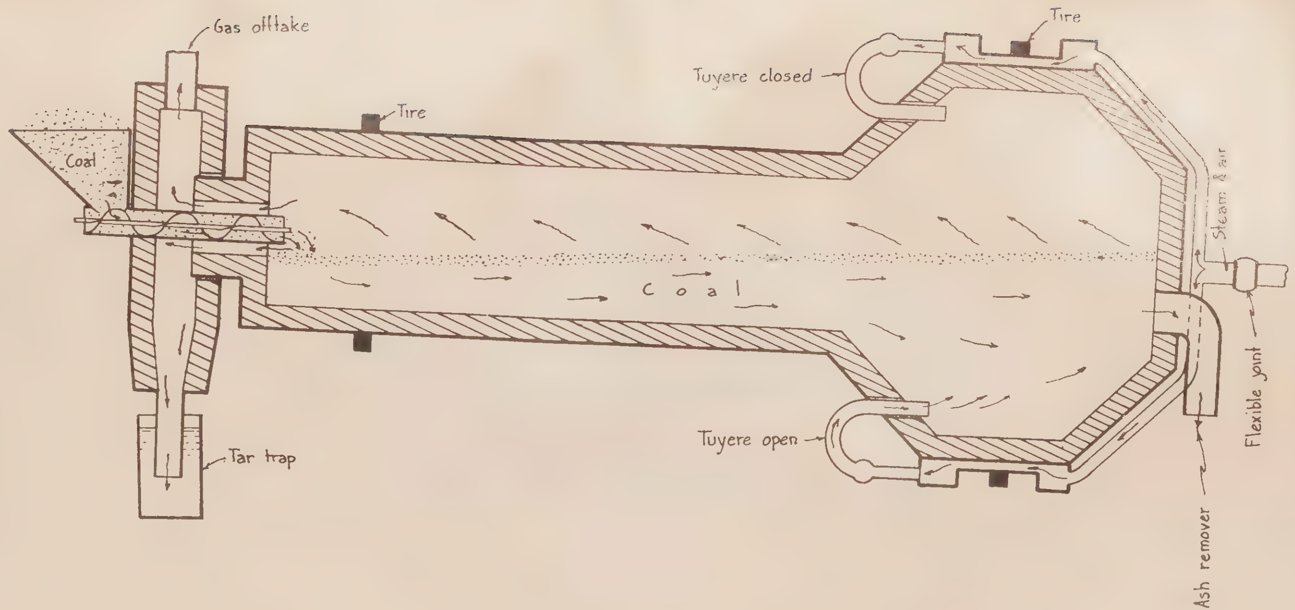
THOMAS CARBONIZING UNIT.

McPherson & Fullerton Bros., Vancouver, B.C.

FIGURE 57

For text reference see page 144

Fig. 58

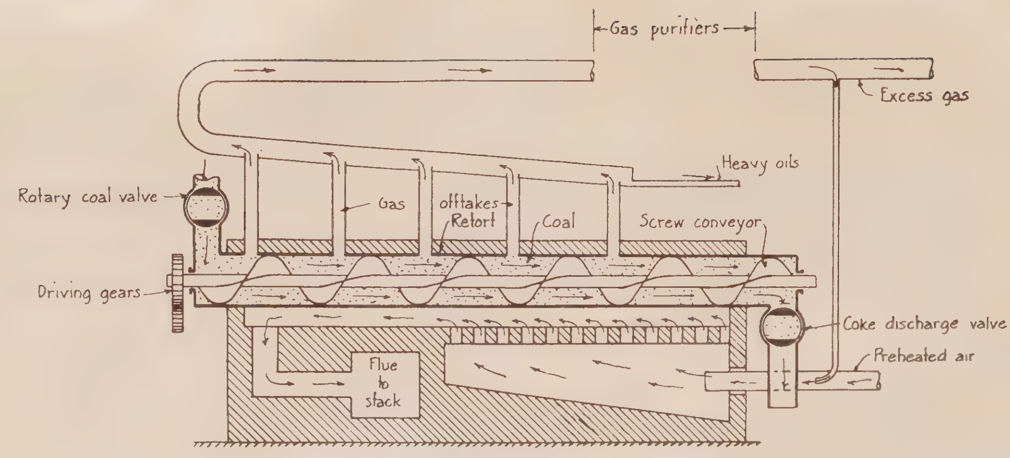


ROTARY GAS PRODUCER.

General Reduction, Gas & By-products Co., New York, N.Y.

FIGURE 58

For text reference see page 144

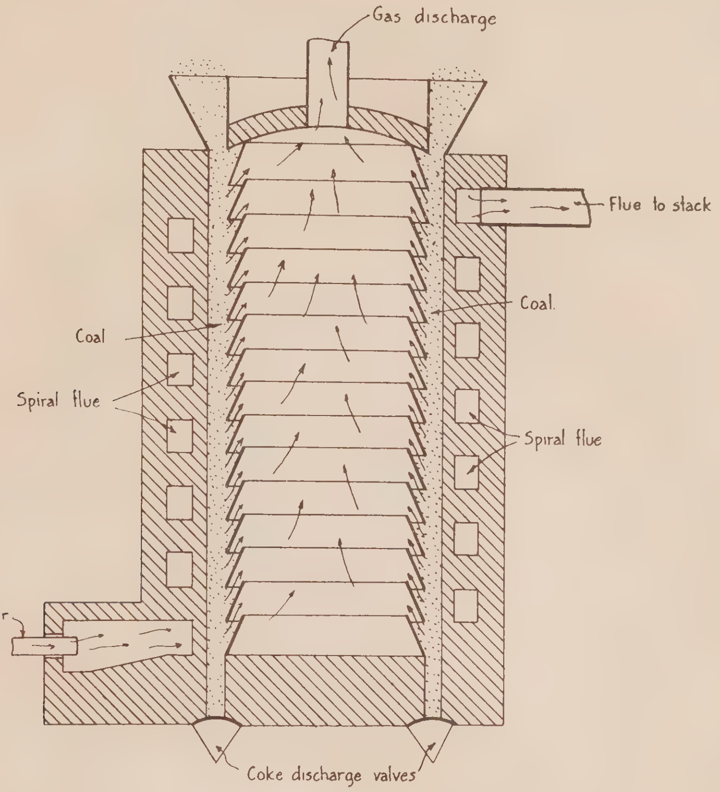


WHITE CARBONIZING UNIT.

Oil & Carbon Products Co. Ltd., London, Eng.

FIGURE 59

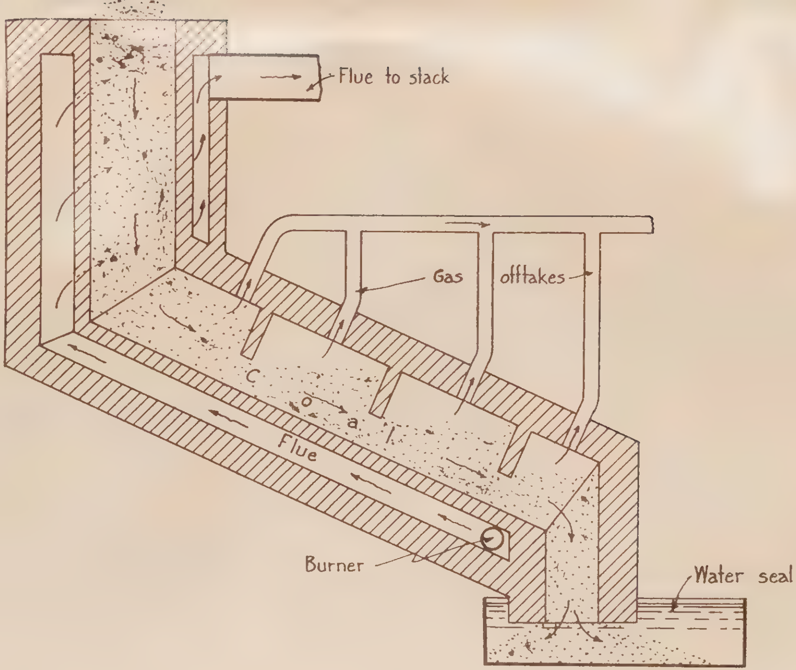
For text reference see page 145



SECTION OF DR. BREDLIK'S RETORT.
Gas & Coke Oven Corpn. of America, New York. N.Y.

FIGURE 60

For text reference see page 145

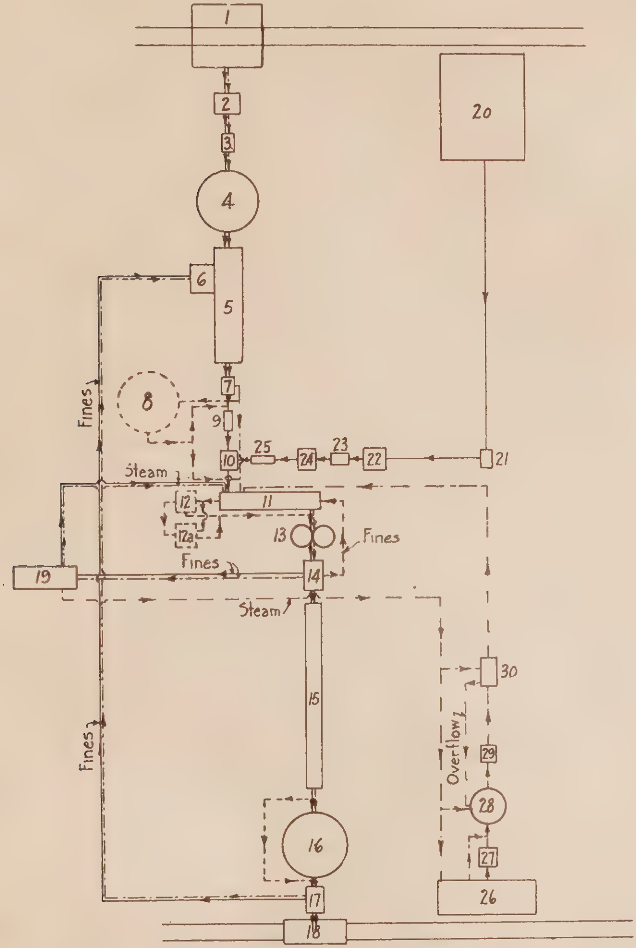


EXPERIMENTAL RETORT.

Prof E.J.Babcock, Univ. of N.Dak., Grand Forks, N.Dak

FIGURE 61

For text reference see page 145



Path of materials through hard pitch plant shown thus ——————

" " " " " " soft " " " " " " — —·— —·—

Alternative routes through either plant with additional equipment sometimes installed, shown thus - - - - - - - - - - -

FLOW SHEET - TYPICAL BRIQUETTING PLANTS.

FIGURE 62

For text reference see page 145

Fig. 64

Fig. 64

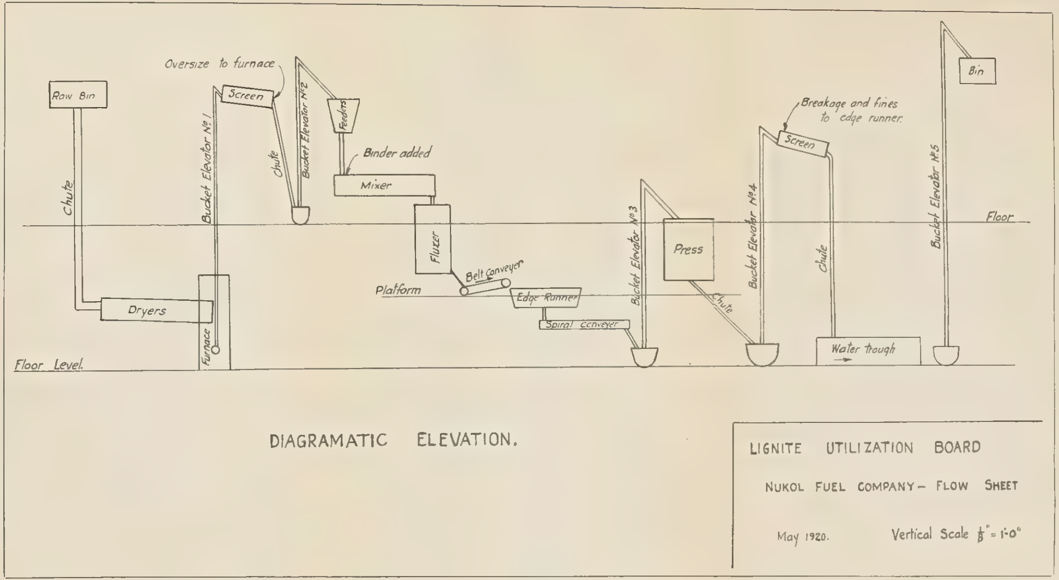


FIGURE 64

Flow sheet of Nukol Plant, Toronto

For text reference see page 223

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